SYSTEM OPERATION ASSESSMENT OF LAKE WRIGHT PATMAN AND LAKE JIM CHAPMAN

Volume I – Main Report

JANUARY 2003

Prepared for:

U. S. ARMY CORPS OF ENGINEERS, FORT WORTH DISTRICT

Prepared by:

Freese and Nichols, Inc.
4055 International Plaza
Suite 200
Fort Worth, TX 76109
817/735-7300

Thomas C. Gooch, P.E.

Jon S. Albright

Andres Salazar, Ph.D

COE02291

SYSTEM OPERATION ASSESSMENT OF JIM CHAPMAN AND WRIGHT PATMAN LAKES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF APPENDICES

1.0 Introduction

1.1. Study Authority

In 2000 the Fort Worth District of the U.S. Army Corps of Engineers (Corps) contracted Freese and Nichols, Inc. (FNI) to prepare the *Texas Water Allocation Assessment Report*. This report was prepared as part of the congressionally authorized Texas Water Allocation Assessment Study (TWAA), an assessment of water issues in Texas. The assessment was based on a review of the Senate Bill One Regional Water Plans, which were completed in January 2001, and interviews with participants and other stakeholders in the state. The *Texas Water Allocation Assessment Report* identified several opportunities for Federal involvement in meeting the future water needs of the State. One of these opportunities is the reallocation of flood storage in Lake Wright Patman.

Based on this opportunity, the Corps initiated an investigation of the additional yield that could be developed in the basin through a variety of alternatives, including reallocations, operational revisions at Lake Wright Patman and/or Lake Jim Chapman, and coordinated operation of Lakes Wright Patman and Jim Chapman. This report details the findings of that investigation. The Corps of Engineers again contracted with FNI to conduct this *System Operation Assessment of Jim Chapman and Wright Patman Lakes,* which under contract DACW63-01-D-0001 dated May 24, 2002. This study is a continuation of studies under the TWAA appropriation.

1.2. Study Purpose and Scope

This study has three major goals:

- To determine the potential gain in supply from implementing alternative operation policies in Lake Wright Patman
- To determine the potential increase in yield if Lakes Wright Patman and Jim Chapman are operated together as a system
- To identify potential opportunities and constraints regarding bottomland hardwood and wetland resources in the Sulphur River Basin resulting from changes in operation. Specifically, the White Oak Creek Wildlife Management Area (WMA) was evaluated with respect to operational changes.

The Scope of this project includes the following tasks:

- Review available hydrologic data for Jim Chapman and Wright Patman Lakes, including daily historical data developed by the Corps of Engineers, data developed for the Texas Commission for Environmental Quality (TC EQ) Water Availability Model for the Sulphur Basin, and data developed in previous Freese and Nichols studies. Develop daily hydrologic data for both reservoirs from 1940 through 2001 for operation studies.
- Develop a daily operation model for Jim Chapman and Wright Patman Lakes incorporating the daily hydrologic data and current operation policies for the lakes.
- Run the operation model with current policies to develop a time history of reservoir elevations, estimated flows at the White Oak Creek Wildlife Management Area (WMA) and spills and releases from the reservoirs under current operating policies. Run the model with the operating rule curve for Wright Patman Lake from the 1968 Contract DACW29-68-A-103 between the Corps and the City of Texarkana (ultimate curve) to develop the same information.
- Conduct meetings between the Corps of Engineers, the Texas Parks and Wildlife Department and the U.S. Fish and Wildlife Service to discuss the White Oak Creek WMA and other potentially impacted resources in the Sulphur River Basin. Identify opportunities and constraints for operating the two lakes as a system based on potential impacts to these resources.
- Place the boundaries of the White Oak Creek WMA on USGS quadrangle maps. Using quadrangle maps, develop an area-elevation relationship for the mitigation area.
- Modify the daily operation model developed to incorporate possible alternative operations for Jim Chapman and Wright Patman Lakes, including:
    - Pumping water from the flood pool of Wright Patman Lake to Jim Chapman Lake to increase the reliable supply from Jim Chapman Lake.

  - Permanent or seasonal changes to the top of conservation storage of either lake.
  - A combination of the above measures.

- Review the Red River Compact and consider limitations imposed by the compact on project operation.
- Using the modified model, analyze possible modifications to current operation for potential system management plan alternatives plus current policies. For each alternative:
  - Determine the reliable supply available from each reservoir.
  - Determine the impact of the policy on lake elevations, flows at the downstream border of White Oak Creek WMA and flows downstream from the lakes.
  - Make a qualitative analysis of the impact of the policy on inundation at the White Oak Creek WMA.
  - Make a qualitative analysis of the impact of the policy on water quality in the lakes.
  - Determine the additional supply available on a less than 100 percent reliable basis and the impact on lake levels and flows of using this less reliable supply.
- Review and refine the potential system management plan alternatives.
- Develop a report describing the analyses conducted and presenting the results. If possible, recommend a plan to increase water supply yield in the Sulphur Basin while protecting and benefiting wetland and bottomland hardwood resources. Include the following:
  - Maps showing current projects, existing intake points and water supply pipelines, and other significant features.

- Recommendations for future studies needed to pursue implementation of the recommended alternatives.

2.0 Project Setting

The System Operation Assessment of Jim Chapman and Wright Patman Lakes is a study of two U.S. Army Corps of Engineers-owned and operated lakes in the Sulphur River Basin in East Texas. The Corps constructed both lakes for the authorized purposes of flood damage reduction and water supply. They are also used for recreational purposes. A brief description of the Sulphur River Basin and lakes is presented in the following sections.

2.1 Description of Project Area

The Sulphur River Basin is located in the northeastern part of Texas as shown on Figure 2.1. The upper basin begins in Fannin and Hunt counties and extends eastward to southwest Arkansas where it joins the Red River. The oblong basin averages 25 miles in width and includes portions of 11 counties in Texas and one county in Arkansas. The Texas portion of the Sulphur River Basin covers approximately 3,600 square miles[1].

The Sulphur River Basin incorporates three distinct vegetative regions that occur in broad belts across the basin. Much of the downstream portion of Sulphur River Basin is located in the Piney Woods Region, which is characterized by large quantities of pine trees. The upper part of the basin lies in the Blackland Prairies Belt, a true prairie with native grasses and few trees. A thin strip of the Post Oak Belt separates the upper and downstream regions. Vegetation in the Post Oak Belt area typically contains stands of post oak and blackjack oak. The bottomlands in all three regions contain mainly oak hardwoods with occasional pecan, elm and hickory.

The climate in the project area is generally mild with frequent rainfall. The average annual temperature in Northeast Texas is 65° F, with a mean annual precipitation of 40 to 47 inches. The first and last freeze dates typically occur in early November and late March, respectively, providing an average growing season of 240 days.

Due to the abundant rainfall, the Sulphur River Basin is a significant source of water supply. There are 29 known impoundments in the basin with storage capacities greater than 200 acre-feet. Most of these impoundments are small, with only five reservoirs providing the majority of impoundment. Lakes Wright Patman and Jim Chapman are the

Figure 2-1

two largest reservoirs in the basin and account for over 85 percent of the authorized diversions in the basin. Table 2-1 gives a summary of the water rights in the Sulphur Basin. A complete listing of water rights is included in Appendix C.

Table 2-1
Summary of Water Rights in the Sulphur River Basin

Location	**Authorized Diversions** (acre-feet/year)
Above Lake Jim Chapman	381
Lake Jim Chapman	146,520
Between Jim Chapman and Wright Patman	
- Main stem of Sulphur River	18,006
- Tributaries	31,796
Lake Wright Patman	180,000
Tributaries between White Oak Creek WMA and Wright Patman damsite	1,648
Total	**378,351**

2.2 Lake Jim Chapman

Lake Jim Chapman, formerly known as Cooper Lake, is located in the upper part of the basin on the South Sulphur River in Delta and Hopkins Counties. Construction was authorized in 1955 for Lake Jim Chapman and associated channels for flood control, water supply and recreation. The construction started in 1959 with 40 miles of levees and 16 miles of channels[2].

Prior to completion of the dam, the project was stopped in 1971 to address requirements of the National Environmental Policy Act (NEPA) of 1969. In compliance with NEPA, an Environmental Impact Statement (EIS) was prepared, and the Final EIS was filed in 1977 with the Council of Environmental Quality (CEQ). In December 1977, the Louisiana Court issued an injunction against the Jim Chapman project detailing inadequacies in the EIS in demonstrating the need for flood control and water supply and for lack of a mitigation plan for losses of fish and wildlife habitat. The Corps of Engineers filed a Draft and Final Supplemental EIS in 1981 with the EPA addressing the inadequacies of the original EIS.

The supplemental impact statements presented a proposal for mitigation to compensate for losses of terrestrial habitat caused by the impoundment of water in Jim Chapman. Two broad areas were proposed as mitigation areas in the upper and lower Sulphur River. First considered was 10,000 acres of reservoir perimeter lands adjacent to Jim Chapman. The second area was an extension of 25,500 acres of mostly bottomland hardwood forests surrounding the junction of the Sulphur River and White Oak Creek between U.S. Highway 30 and Wright Patman Reservoir, known as the White Oak Creek Wildlife Management Area[3] (WMA).

Since the management of perimeter lands alone was not enough for mitigation, the Corps and the US Fish and Wildlife Service recommended the White Oak Creek WMA to compensate for habitat losses caused by the impoundment of water in Lake Jim Chapman[2]. It was further recommended that the Texas Parks and Wildlife Department oversee the Operation and Maintenance (O&M) of habitat mitigation lands, with costs for O&M shared by the Corps and project sponsors. These recommendations were submitted to Congress, and the habitat mitigation plan was subsequently authorized by the Water Resources Development Act of 1986.

Although the Supplemental EIS was filed in 1981, the Court continued the injunction. After a process of appeals, oral arguments, public hearings, and submittal of the habitat mitigation plan for Congressional Authorization, the Court ruled in 1984 that the Supplemental EIS was adequate, and the construction of the project was allowed to continue. Construction of the reservoir and concurrent acquisition of mitigation lands by the Corps started in December 1986, and impoundment of water began on September 28, 1991.

2.2.1 Description of Dam and Lake

Cooper dam is an earthen embankment that is 28,070 feet long with a maximum height of 79.5 feet above the streambed. The dam is operated primarily for flood control purposes with about 146,500 acre-feet per year in permitted diversions for water supply. The outlet works are located near the southeast end of the dam and include an approach channel, an intake and control structure, one conduit, a stilling basin, and a discharge channel. The spillway is located in the south abutment, and consists of an approach channel, a 700-foot weir, a stilling basin and a discharge channel. Pertinent data on the dam and lake are presented in Table 2-2.

Water supply from Jim Chapman is governed through contracts with the Corps and water rights permits issued through the Texas Commission on Environmental Quality (TCEQ), formerly the Texas Natural Resources Conservation Commission (TNRCC). A listing of the Corps contracts is shown in Table 2-3, and the water rights are listed in Table 2-4.

Table 2-2
Pertinent Data on Lake Jim Chapman and Cooper Dam

Drainage Area[4]	479 square miles	
Emergency Spillway[5]		
Crest elevation	446.2 feet NGVD *	
Length	700 feet	
Type	Uncontrolled Ogee Weir	
Maximum capacity	134,700 cfs	
Outflow Works		
Type	1 gate-controlled conduit	
Invert elevation	394.0 feet NGVD	
Maximum capacity	3,896 cfs	
Elevations		
Top of dam	464.5 feet NGVD	
Maximum design water surface	459.5 feet NGVD	
Top of flood control pool	446.2 feet NGVD	
Top of conservation pool	440.0 feet NGVD	
Top of sediment pool	415.5 feet NGVD	
Streambed	386.0 feet NGVD	
Yield with 100 years of sedimentation[5]	109.2 mgd	122,372 af/yr
Current Yield[6]	123.4 mgd	138,252 af/yr

* NVGD – National Geodetic Vertical Datum

Table 2-3
USACE Contracts for Lake Jim Chapman

DACW29-68-A-0099	City of Irving	36.859% of the storage and yield of the reservoir between 440.0 and 415.5 feet
DACW29-68-A-0100	North Texas Municipal Water District	36.859% of the storage and yield of the reservoir between 440.0 and 415.5 feet
DACW29-68-A-0101	Sulphur River Municipal Water District	26.282% of the storage and yield of the reservoir between 440.0 and 415.5 feet
DACW29-68-A-0102	Texas Water Development Board	32,100 acre-feet of storage space and dam modifications associated with construction of Sulphur Bluff Reservoir (George Parkhouse)

Table 2-4
Water Rights Listing for Lake Jim Chapman

Water right number[7]	Owner	Use Type	Amount (acre-ft/yr)	Priority
CA 4797	Sulphur River Municipal Water District	Municipal	23,746 [a]	11/19/1965
		Industrial	11,560 [b]	11/19/1965
		Total	*35,306*	*11/19/1965*
CA 4798	North Texas Municipal Water District	Municipal	57,214	11/19/1965
CA 4799	City of Irving	Municipal	44,820	11/19/1965
		Industrial	9,180	11/19/1965
		Total	*54,000*	*11/19/1965*
Total for all water rights		Municipal	125,780	11/19/1965
		Industrial	20,740	11/19/1965
		Total	*146,520*	*11/19/1965*

Notes: [a] 11,247 af/yr for the City of Commerce
[b] 4,832 af/yr for the City of Commerce

2.3 Lake Wright Patman

Lake Wright Patman, formerly known as Lake Texarkana, is located on the Sulphur River in Bowie and Cass counties, approximately seven miles upstream of the Texas-Arkansas border. This reservoir was built as part of a comprehensive plan for flood control on the Red River below Denison, Texas. When originally constructed, the damsite controlled about 91 percent of the drainage area in the Sulphur Basin, 3,400 square miles. Lake Jim Chapman now controls nearly 500 square miles in the upper part of basin.

Construction of Lake Wright Patman was initiated in August 1948 with the clearing of the dam site. The dam was completed in 1953 and the reservoir was operated as a temporary detention basin until impoundment of water began on June 27, 1956. Lake Wright Patman is the largest reservoir in the Sulphur Basin. The total storage beneath the top of the flood control pool is 2,612,145 acre-feet. Most of this volume is used for the flood storage. Storage for water supply varies in accordance with operating policies, which are discussed in detail in Chapter 4.

2.3.1 Description of Dam and Lake

The Wright Patman dam is a rolled earthfill embankment approximately 18,500 feet in length with a crown width of 30 feet. The top of the embankment stands 106 feet above the streambed. The outlet structure consists of four hydraulically operated slide gates, two 20-ft diameter conduits, and a stilling basin. The maximum discharge through the outlet works is 27,600 cfs. The spillway is located south of the outlet structure and is designed to discharge 63,200 cfs. Pertinent data on the dam and lake are presented in Table 2-5.

The City of Texarkana (located in both Texas and Arkansas) has contracts with the Corps for municipal and industrial water supply from Wright Patman. A listing of the Corps contracts is shown in Table 2-6. The Texas water rights permits issued through the TCEQ are listed in Table 2-7.

Table 2-5
Pertinent Data on Lake Wright Patman and Wright Patman Dam

Drainage Area[8]	3,443 square miles
Emergency Spillway	
Crest elevation	259.5 feet NGVD
Length	200 feet
Type	Ogee weir
Maximum capacity	63,200 cfs
Outflow Works[9]	
Type	2 gate-controlled conduits
Invert elevation	200.0 feet NGVD
Maximum capacity	27,600 cfs
Elevations[8]	
Top of dam	286.0 feet NGVD
Maximum design water surface	278.9 feet NGVD
Top of flood control pool	259.5 feet NGVD
Top of conservation pool	variable, minimum 220.6 feet NGVD, maximum 227.5 NGVD
Sediment pool	40,800 acre-feet (no elevation given, assumed to be 215.25 feet NVGD)
Streambed	180.0 feet NGVD

Yield*

Interim	103.5 mgd	115,984 af/yr with 50 years of sedimentation
Ultimate	162.5 mgd	182,100 af/yr with 50 years of sedimentation

* See section 4.2

Table 2-6
USACE Contracts for Lake Wright Patman

DA-16-047-eng-2033	13 mgd (14,568 af/yr) to Texarkana
DACW29-68-A-0103	120,000 acre-feet of reallocated additional storage to Texarkana after Lake Chapman is completed
DACW29-69-C-0019	Additional 84 mgd (94,132 af/yr) to Texarkana, pending implementation of contract above
Total Contracts	97 mgd (108,700 af/yr)

Table 2-7
Water Rights Listing for Lake Wright Patman

Water right number[7]	Owner	Use Type	Amount (acre-ft/yr)	Priority
CA 4836	City of Texarkana	Municipal	45,000	3/5/1951
		Industrial	135,000	2/17/1957
		Total	*180,000*	

2.4 White Oak Creek Wildlife Management Area

The White Oak Creek Wildlife Management Area (WMA) covers approximately 25,500 acres in Bowie, Cass, Morris, and Titus Counties. It is located immediately upstream of Wright Patman and includes acreage along the Sulphur River and White Oak Bayou as shown on Plate 1. Much of the area is forested bottomland and is subject to periodic overflow from these rivers.

As previously discussed, Congress designated the White Oak Creek WMA as a protected habitat and wildlife management area to mitigate the habitat losses associated with the construction of Jim Chapman Lake. This area was selected primarily because of its high quality bottomland hardwood forests and waterfowl habitat. There are nearly 17,000 acres of bottomland hardwood forests in the mitigation area, which is about 68 percent of the total area. Most of the remaining acreage consists of pine hardwood forests and upland pastures. Of the numerous birds and wildlife known to occur in this habitat, the mallard and wood duck are recognized as species of concern in East Texas by the U.S. Fish and Wildlife Service. The White Oak Creek WMA is an important wintering area and top production area for wood ducks and is a wintering habitat for mallards.

The White Oak Creek WMA also provides habitat for other wildlife and aquatic species. Recreational opportunities within the mitigation area include fishing, hunting, camping and hiking. The Texas Parks and Wildlife Department manages the White Oak Creek WMA and oversees the development of recreational facilities.

Most of the White Oak Creek WMA is located in the flood easement of Lake Wright Patman. Table 2-8 gives a relationship between elevation and area at the WMA developed from USGS topographic maps (Currently, these maps are only available at 10-foot contour intervals). Plate 1 is a map of the WMA showing the contours. The relationship between water surface elevation at Lake Wright Patman and inundation at the WMA is complex because it is also dependent on the flow in the river and location within the WMA. This relationship between flow and water surface elevation is referred to as the 'backwater effect'. At the maximum current conservation storage of 227.5 feet NVGD the reservoir may back up some water into the WMA, most of which is contained within river channels. During flood periods it can be expected that water from the reservoir will inundate some of the WMA. At the top of controlled flood storage in Lake Wright Patman, 73% of the WMA would be flooded based on the water surface elevation of the reservoir alone. High flows in the rivers at the same time may make the water surface elevation even higher, flooding more of the WMA. However, floods of this magnitude occur very rarely. Most flood events would be contained in the lower part of the flood pool.

Table 2-8
Relationship between Water Surface Elevation and Inundation at the White Oak Creek WMA

Water Surface Elevation (ft)	**Inundated Area** (acres)
230	496
240	3,800
250	12,134
260	18,832
270	22,572
280	23,415

[1], R. J. Brandes Company, *Draft Water Availability Model for the Sulphur River Basin,* prepared for the Texas Natural Resource Conservation Commission, January 1999.

[2] US Army Corps of Engineers. Fort Worth District. *Cooper Lake, Sulphur River, Texas, Master Plan Design Memorandum No. 10*. May 1987.

[3] Texas Parks and Wildlife Department. *White Oak Creek Management Area.* http://www.tpwd.state.tx.us/post_oak/wma/white_oak_creek/whiteoak_creek_index.htm

[4] Fred Jensen, U.S. Army Corps of Engineers Fort Worth District, personal communication

[5] U.S. Army Corps of Engineers Fort Worth District, *Jim Chapman Lake Cooper Dam Water Control Manual Chapter 7*, June 1999.

[6] Freese and Nichols, Inc. et al., *Region C Water Plan,* January 2001.

[7] Texas Natural Resource Conservation Commission, Water Rights database, available online at http://www.tnrcc.state.tx.us/permitting/waterperm/wrpa/permits.html#databases

[8] U.S. Army Corps of Engineers Fort Worth District, available online at http://www1.swf-wc.usace.army.mil/pertdata/txkt2.pdf

[9] U.S. Army Corps of Engineers New Orleans District, *Wright Patman Appendix I Master Reservoir Regulation Manual*, September 1974.

3.0 Modeling Approach

3.1 Introduction

The primary tool used in this study is a computer model developed specifically for this project. The computer model is based on the program OPERATE, a proprietary general-purpose reservoir operation model developed by FNI, which has been used for hundreds of projects in Texas and elsewhere. The model uses a daily time step and historical hydrology covering the period from 1940 through 2001. The model is capable of simulating a variety of operational policies to evaluate the overall yield of the two reservoirs. Components of the model include:

- Operation of Lake Jim Chapman and Lake Wright Patman, including reservoir content, inflows, spills and releases, evaporative losses and reservoir demands.
- Flows between the reservoirs at USGS gages 07342500 (South Sulphur near Cooper) and 07433210 (Sulphur River below Talco), and at the Highway 67 bridge in the White Oak Creek WMA.
- Delivery of water from Lake Wright Patman to Lake Jim Chapman at various pumping rates.

This chapter contains a general overview of the approach used in the model. A more detailed explanation of the model's capabilities may be found in Appendix C.

3.2 Hydrology

The hydrology used in the model consists of historical data covering the period from 1940 to 2001. These data may be grouped into two categories:

- Inflows, which consist of historical inflows into the reservoirs and streamflows at selected locations between the reservoirs. These inflows were adjusted to current conditions. This adjustment process is described in Section 3.2.1 of this report.
- Net reservoir evaporation rates, which are used to calculate losses or gains due to evaporation from and precipitation on a reservoir's surface.

3.2.1 Inflows

The historical inflow data used in this study are based on inflows developed in previous projects. Three sources of inflow data were evaluated:

- Inflows derived from the Sulphur Basin Water Availability Model (WAM) sponsored by the Texas Commission on Environmental Quality (TCEQ),
- Freese and Nichols inflows developed in previous studies, and
- Corps inflows used in the Red River Basin SUPER Model, a model primarily used by the Corps to simulate flood operations in the basin.

A detailed comparison of these inflows may be found in Appendix C. Based upon these comparisons, the TCEQ Sulphur WAM flows were selected for the following reasons:

- *Consistency with the State water rights permitting process.* It is likely that implementation of the results of this study would require amendments to the TCEQ water rights permits for Lakes Wright Patman and Jim Chapman. This process may be facilitated if the modeling that is the basis for this amendment is consistent with established TCEQ procedures. It is noted, however, that modifications to operating rule curves would be based on Corps models and analyses.
- *Full accounting for existing water rights.* The WAM inflows account for all existing water rights in the Sulphur Basin at the time of model development.
- *Changes from historical operation of Lake Wright Patman.* It is likely that any proposed operation of Lake Wright Patman would be substantially different from the historical operation of the reservoir. The WAM inflows were developed so that precipitation on the reservoir surface is accounted for in the evaporation rates used in the modeling process, which allows accurate modeling of changes from historical reservoir operations.

The TCEQ WAM flows are available only from 1940 to 1996, while the study scope required simulation through 2001. Flows were extended through 2001 using a statistical relationship between the Corps SUPER Model flows and the TCEQ WAM flows.

The TCEQ WAM uses a monthly time step, while the approach used in this study requires a daily time step. The WAM monthly flows were distributed on a daily basis by multiplying the monthly flows by the percentage of the month's flow that historically occurred at each location. USGS gage data were used to determine these percentages where available. In cases where gage data were missing or incomplete, Corps Super Model daily flows were used.

The inflow data used in the model may be found in Appendix D.

3.2.2 Net Reservoir Evaporation Rates

Net reservoir evaporation rates are used in the model to calculate the impacts of evaporation and precipitation on the surface of a reservoir. Evaporation and precipitation rates for each reservoir were combined into a single factor referred to as *net reservoir evaporation*. Net reservoir evaporation is defined as:

Net Evaporation = Evaporation – Precipitation + Effective Runoff

Where

Evaporation is the measured historical evaporation rate at the reservoir

Precipitation is the measured historical precipitation at the reservoir

Effective Runoff is the amount of precipitation that would have contributed to streamflow if the reservoir had not been in place.

Net evaporation rates were based on historical evaporation and precipitation data developed by the Texas Water Development Board. These data are available on a monthly basis. Daily net evaporation rates were developed by distributing the monthly rates evenly for each day in the month. More detailed information on the evaporation calculations may be found in Appendix C.

3.3 Reservoirs

There are two main components to each reservoir in the model:

- A table relating the capacity, area and elevation of the reservoir
- Operation rules governing spills and releases from the reservoirs

3.3.1 Area-Capacity Tables

Area-Capacity tables define the relationship between storage capacity, surface area and water surface elevation. These tables are used in the model to relate the amount of water in storage to the surface area of the reservoir. The surface area is multiplied by the evaporation rate to determine the net amount of water lost to evaporation and gained by precipitation on the reservoir surface. The content of a reservoir is calculated iteratively because the end-of-day content is dependent upon the change in the surface area of the reservoir (and therefore evaporation).

The area and capacity tables used in this study were provided by the Corps and may be found in Appendix D. The Lake Jim Chapman survey is the original area capacity relationship for the reservoir, which was closed in 1991. The Texas Water Development Board conducted a volumetric survey of the conservation storage of Lake Wright Patman in 1997. The Corps extended the 1997 survey to include the data above 230 feet NGVD. The existing area-capacity relationships were used in the model without adjustment for sedimentation. Sedimentation rates in the Sulphur Basin are generally low, so the storage capacities of the two reservoirs should not be significantly different from the storage measured in the latest surveys.

3.3.2 Reservoir Operation

Reservoir operation refers to the rules governing releases and pumping from a reservoir. Release rules include low-flow releases that occur when the reservoir is below top of conservation storage and rules governing releases from the flood storage. In this model, pumping rules refer to reservoir states that initiate pumping from Lake Wright Patman to Lake Jim Chapman or rules that govern interruptible supplies. The model is able to simulate a variety of rule curves, zones and release options for each reservoir.

3.3.3 Lake Jim Chapman Operation

Operation criteria for Lake Jim Chapman were derived from the June 1999 Corps publication *Jim Chapman Lake Cooper Dam Water Control Manual*. Tables 3-1 and 3-2 are a summary of current release rules from the manual. More detailed information on Lake Jim Chapman release rules may be found in Appendix C.

Table 3-1
Current Lake Jim Chapman Operational Releases

Reservoir Elevation	Minimum Release	Maximum Release
Below 440.0 ft. (top of conservation pool)	5 cfs or the amount required to meet downstream water rights, whichever is greater	None, subject to downstream control
440.0 ft to 440.4 ft.	50 cfs plus inflow or amount to bring reservoir to 440.0 ft.	3,000 cfs, subject to downstream control
440.4 ft to 441.0 ft.	1,000 cfs plus inflow	3,000 cfs, subject to downstream control
441.0 ft to 446.2 ft. (top of controlled flood pool)	3,000 cfs	3,000 cfs, subject to downstream control
446.2 ft to 447.5 ft.	Calculated from spillway rating curve plus amount that will not exceed downstream control	6,000 cfs
Above 447.5 ft	Calculated from spillway rating curve	Calculated from spillway rating curve

Table 3-2
Downstream Control for Lake Jim Chapman Releases

Control Location	Maximum Flow
South Sulphur River near Cooper	6,000 cfs
Sulphur River near Talco	34,000 cfs
Red River at Shreveport	Not modeled

There were four operational criteria specified in the control manual that were not incorporated into the model:

- *Maximum flows for the Red River at Shreveport gage.* The modeling approach does not include flows downstream of Lake Wright Patman, so downstream releases are not limited by flows at the Shreveport gage.

- *Balancing flood storage with other reservoirs in the Red River Basin.* Similarly, we did not include simulation of other reservoirs in the Red River Basin (other than Lake Wright Patman) in the model.

- *Mosquito control.* The manual specifies that releases may be increased above 5 cubic feet per second (cfs) to maintain a lowering of the reservoir water surface elevation by 0.2 feet over a 10-day period between May and October for mosquito control. This operation appears to be optional and was not included in the operational procedures coded into the model.

- *Pool accounting procedures.* The manual gives the procedures for dividing storage between the various water rights holders in the reservoir. The pool accounting system is unrelated to increasing water supply from Lakes Wright Patman and Jim Chapman and was not included in the model.

3.3.4 Lake Wright Patman Operation

The Corps operates Lake Wright Patman with a variable conservation pool elevation. Three families of curves governing operation were considered in this study:

- The *interim curve*, which is the curve that currently governs reservoir operation

- The *ultimate curve*, which is the curve proposed in the Corps contract with the City of Texarkana

- Various constant level conservation storages ranging from 223.0 feet to 229.0 feet

The interim and ultimate curves are displayed graphically in Figure 4-3. Each of these curves will have different impacts on the yield of the reservoir and system operation. The impact of these curves on yield is discussed in Chapter 4. System operation is discussed in Chapter 5.

Release rules are based on the *Wright Patman Lake Master Regulation Manual Appendix I*[1]. If the reservoir is above the top of conservation storage, releases are set to 10,000 cfs. If the reservoir is at or below the top of conservation storage the model sets releases at either 10 cfs or 96 cfs, depending on the time of year and reservoir elevation. Releases from conservation storage are discussed in more detail in Appendix C and Section 4.2.

When the reservoir is above conservation storage the Lake Wright Patman control manual specifies three main control criteria:

- Changes in release rates will cause a 4-foot maximum change in tailwater elevation (water in the channel below the dam).
- Releases will be reduced to prevent flooding at Shreveport (stages above 31 feet).
- The maximum release is 10,000 cfs.

Tailwater elevations and reduced releases were not included in the model because these criteria are dependent on downstream conditions, which are outside the scope of this study. To approximate the tailwater criterion, we assumed that the maximum change in release rate is 4,000 cfs per day based upon parameters from the SUPER model.

3.4 Routing between Lake Jim Chapman and Lake Wright Patman

In this study, routing refers to the transfer of outflows from Lake Jim Chapman to Lake Wright Patman. Flow from Lake Jim Chapman takes several days to reach Lake Wright Patman, and peaks in flow are somewhat attenuated as the water flows downstream. This model simulates daily flows at four control points:

- South Sulphur near Cooper
- Sulphur River near Talco
- The crossing of Highway 67 in the White Oak Creek WMA
- Lake Wright Patman.

The South Sulphur River near Cooper and Sulphur River below Talco are included because flows at these points are part of the flood release operations from Lake Jim Chapman (See Table 3-2.) The Highway 67 control point is used to estimate the impacts of changes in operation on the White Oak Creek WMA (See Section 3.7.)

For the model, daily flows were developed at each control point. These flows do not include flows originating above Lake Jim Chapman or spills and releases from Lake Jim Chapman. The model calculates outflows from Lake Jim Chapman based upon the operating rules built into the model (see Section 3.3.3). These flows are then added to the flows at the downstream control points, subject to time delays and storage along the reach based on a Modified Muskingum method developed by the Corps. More detailed information on routing may be found in Appendix C.

The Highway 67 bridge is used as a control point for evaluation of streamflow and inundation in the White Oak Creek WMA. The bridge is at or near the former location of the Sulphur River near Darden gage and is located a few miles upstream of the eastern border of the WMA. This location has several years of recorded historical flows prior to the construction of Lake Wright Patman to aid in development of streamflows at that location.

3.5 Pumping from Lake Wright Patman to Lake Jim Chapman

The model uses a zone system to determine delivery from Lake Wright Patman to Lake Jim Chapman, a process that Freese and Nichols has successfully used in many system operation models. The conservation and flood storage of each reservoir was divided into three to five zones that may vary seasonally. The user assigned pumping rates to each zone combination. The impact of pumping from Lake Wright Patman to Lake Jim Chapman is discussed in Chapter 5.

3.6 Demands

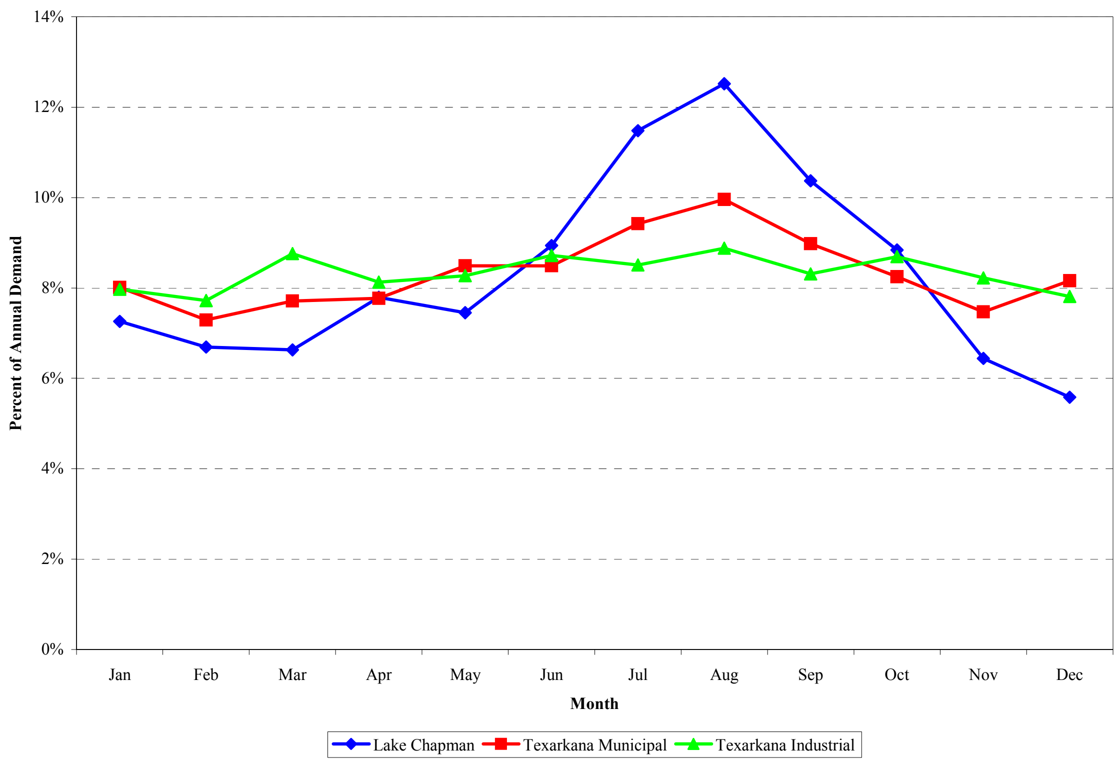
There are five types of demands included in the model:

- Municipal local demands at Lake Wright Patman
- Industrial local demands at Lake Wright Patman
- Local demands at Lake Jim Chapman
- System demands diverted from Lake Jim Chapman
- Interruptible system demands diverted from Lake Jim Chapman

The local demands at the reservoirs correspond to current water diversions and contracts from the reservoirs. Industrial demand will be modeled separately for Lake Wright Patman because the reservoir has a large industrial demand with a significantly different diversion pattern from local municipal demands. Local demands from Lake Jim Chapman are assumed to be primarily municipal. System demand corresponds to the reliable increase in supply made available by operating the reservoirs in a coordinated way. Interruptible system demand is the amount of water that may be available from the reservoir system on a less than 100 percent reliable basis. System demands and interruptible demands are assumed to be primarily for municipal supply.

Annual demands are entered into the model, which are distributed to each month for a typical pattern of use throughout the year. Demand patterns are based on data from the Sulphur Basin Water Availability Model. Figure 3-1 is a graphical representation of the typical patterns. The monthly demands are then distributed evenly on a daily basis.

Figure 3-1
Typical Monthly Demand Patterns



We assumed that all system demands (reliable and interruptible) are diverted from Lake Jim Chapman. Pumping from Lake Wright Patman to Lake Jim Chapman backs up the supply. System demands from Lake Jim Chapman are not directly related to pumping from Lake Wright Patman. Pumping from Lake Wright Patman to Lake Jim Chapman is determined by pumping rules based on reservoir elevations, which are indirectly related to demand. See Section 5.2 for additional information.

3.7 Impact on the White Oak Creek WMA

The study calls for a qualitative analysis of the impact of operation policies on the White Oak Creek WMA. Flows at Highway 67 in the management area were analyzed for changes in flow frequency that could potentially impact the WMA. An existing backwater model from the Corps was used to determine the approximate water surface elevation at the bridge. This information, in combination with the area-elevation relationships developed in as part of this project, was used to evaluate the inundation frequency at the management area. These impacts are discussed in Chapters 4 and 5.

3.8 Red River Compact

The study area is located in Subbasin 4 of the Red River Compact. According to Section 5.04(b), the "State of Texas shall have the free and unrestricted use" of water above Lake Wright Patman. Therefore the Red River Compact does not affect the operation of either Lake Wright Patman or Lake Jim Chapman.

---

[1] U.S. Army Corps of Engineers New Orleans District, *Wright Patman Appendix I Master Reservoir Regulation Manual*, September 1974.

4.0 Stand-Alone Yields

The storage in Corps of Engineers reservoirs is typically divided into four zones:

- Conservation storage, which is the portion of the reservoir reserved for water supply, recreation and other similar purposes.
- Sediment storage, which is the portion of reservoir storage reserved to accumulate sediment over the life of the reservoir.
- Flood storage, which is the portion of reservoir storage above conservation storage and below the emergency spillway. Controlled flood releases can be made from this zone.
- Uncontrolled flood storage, which is reservoir storage above the top of the emergency spillway but less than the maximum safe storage in the reservoir.

For this study, we have defined reliable supply as the amount of water that can be diverted from the conservation storage of a reservoir every year during a repeat of historical hydrologic conditions while not impacting the ability of other water rights holders to divert and store water or incurring a shortage. In this chapter we will discuss the stand-alone yield of Lakes Wright Patman and Jim Chapman. The *stand-alone yield* is the reliable supply available from each reservoir operating independently of the other.

4.1 Lake Jim Chapman Stand-Alone Yield

The stand-alone yield of Lake Jim Chapman was evaluated under two conditions:

- Current operating policies and
- Wildlife management goals provided by the Texas Parks and Wildlife Department (TPWD).

The yield under each of these conditions is summarized in Table 4-1.

Table 4-1
Stand-Alone Yield Runs for Lake Jim Chapman

Run ID	**Description**	**Conservation Pool Elevation** (Ft)	**Stand-Alone Yield** (Ac-ft/yr)
C-1	Current operations	440	128,600
C-2	Wildlife management goals	Variable*	108,533

* See Figure 4-1

For this study no releases were made from Lake Jim Chapman for Lake Wright Patman, which has a senior water right. Under Texas Law, water right holders in Lake Wright Patman could call on inflows into Lake Jim Chapman whenever there is insufficient flow to meet its water right. However, this study focuses on the operation of the two reservoirs as a system. It is unlikely that inflows would be passed from Lake Jim Chapman to Lake Wright Patman if the two reservoirs were operated as a system. Therefore, in this study the stand-alone yield of Lake Jim Chapman is completely independent of the operation of Lake Wright Patman.

In this study releases occasionally are made from Lake Jim Chapman to meet downstream senior water rights other than Lake Wright Patman. Water from the 5 cfs low-flow release is considered to be available for diversion by these water rights. However, if the 5 cfs release is not sufficient to ensure the reliability of these water rights, additional water is released from the reservoir.

4.1.1 Current Conditions

Run C-1 determined the stand-alone yield of Lake Jim Chapman based on current operational rules as defined in the *Jim Chapman Lake Cooper Dam Water Control Manual Chapter 7*[1]. Lake Jim Chapman has a constant conservation pool elevation of 440.0 ft NVGD. Releases from flood storage (storage above the conservation elevation) are governed by the release rules described in Chapter 3 Section 3.3.3. Below 440.0 ft., a minimum low-flow release of 5 cfs is required.

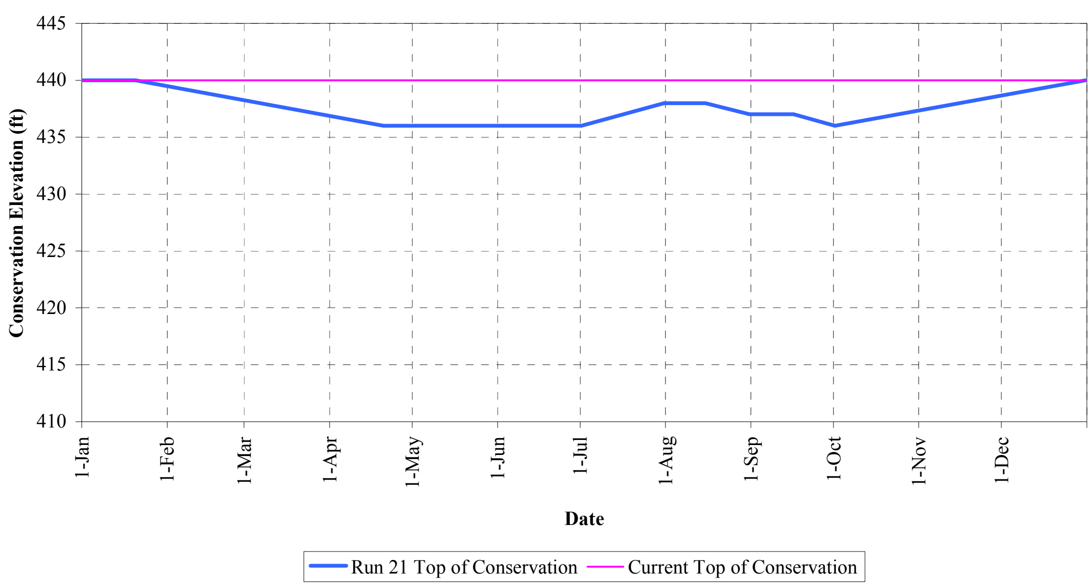
Run C-1 gives a stand-alone yield for Lake Jim Chapman of 128,600 acre-feet per year. The yield is 17,920 acre-feet less than the permitted diversion of 146,520 acre-feet per year authorized by the reservoir’s water right issued by the State of Texas. The yield would be somewhat higher if the reservoir were operated to be empty at the end of the critical period rather than at the top of the sediment pool (415.5 feet NVGD).

4.1.2 Wildlife Management Goals

A July 30, 2002, memorandum by John Jones, Manager of the White Oak Creek Wildlife Management Area for the Texas Parks and Wildlife Department (TPWD), describes the operating criteria for Lake Jim Chapman that are designed to achieve wildlife management objectives for the mitigation areas located at that reservoir[2]. This memorandum may be found in Appendix B. The Lake Jim Chapman operating criteria provided by TPWD calls for a slow drop in reservoir elevations from mid-January through late April followed by a slight rise in reservoir elevations in mid-summer. Starting in mid-August the reservoir elevation goes through two fairly rapid drops until the beginning of October. The reservoir elevation then rises to current top of conservation storage by the end of the year.

Run C-2 is a series of system operation simulations that incorporate these criteria by altering the conservation storage of Lake Jim Chapman. Figure 4-1 is a graph of the conservation storage used in Run C-2. All other release rules remain identical to current operating policies. Using the wildlife management goals results in a stand-alone yield of 108,533 acre-feet per year.

Figure 4-1
Lake Jim Chapman Top of Conservation Storage
Run C-2: TPWD Wildlife Management Goals



4.1.3 Comparison of Lake Jim Chapman Stand-Alone Yields

Table 4-1 summarizes the two stand-alone runs for Lake Jim Chapman. Using the wildlife management goals reduces the stand-alone yield of Lake Jim Chapman from 128,600 acre-feet per year to 108,533 acre-feet per year, a loss of approximately 15.6%. In general, elevations are somewhat lower using the wildlife management goals as well.

More detailed information from the simulation runs may be found in Appendices E and G.

4.2 Lake Wright Patman Stand-Alone Yields

The stand-alone yield of Lake Wright Patman was determined using four basic operating criteria:

- The current operating rule curve, known as the interim curve
- The operating curve specified in a contract between the Corps and the City of Texarkana
- Flat conservation storages ranging from 223.0 feet to 228.64 feet NVGD
- The interim rule curve with a maximum of 50,000 acre-feet of additional storage

These rule curves define the top of conservation storage for Lake Wright Patman. For each rule curve two or more different minimum storage criteria were used. The yield under each of these policies is summarized in Table 4-2.

Table 4-2
Stand-Alone Yield Runs for Lake Wright Patman

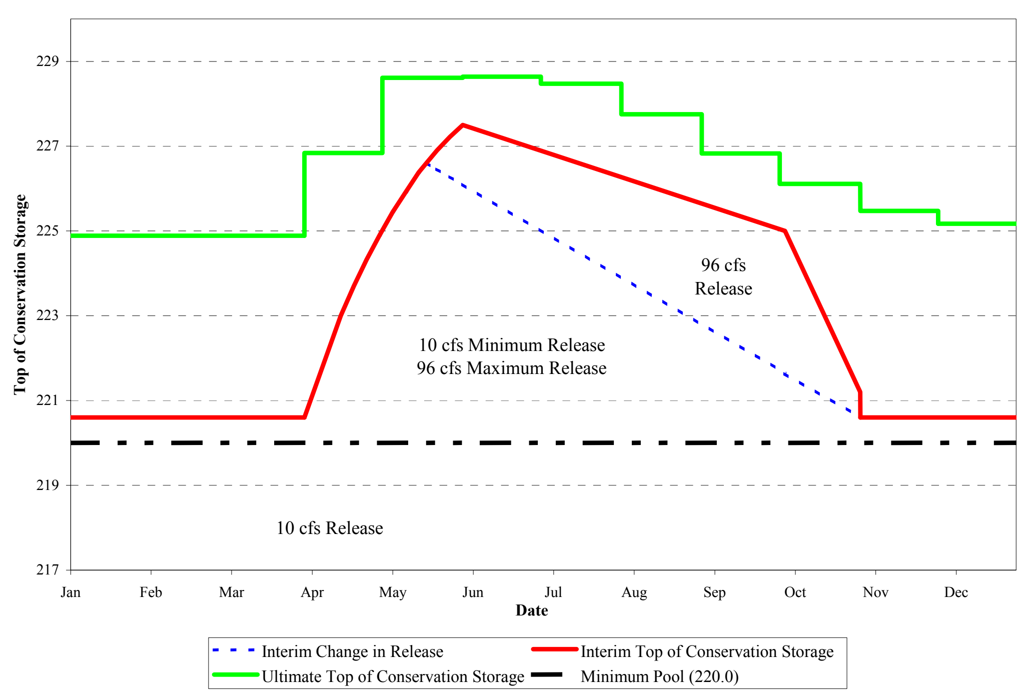
Run ID	**Conservation Pool Rule Curve**	**Minimum Elevation** (ft)	**Stand-Alone Yield** (ac-ft/yr)
I-1	Interim	220	8,974
I-2		217.5	104,397
I-3		215.25	154,205
U-1	Ultimate	220	184,591
U-2		217.5	255,194
U-3		215.25	301,580
U-3a	Ultimate Stair-step	215.25	301,450
F23-1	Flat at 223.0	220	0
F25-1	Flat at 225.0	220	116,499
F27-1	Flat at 227.0	220	211,414
F28-1	Flat at 228.64	220	275,313
F23-2	Flat at 223.0	215.25	163,331
F25-2	Flat at 225.0	215.25	229,788
F27-2	Flat at 227.0	215.25	300,489
F28-2	Flat at 228.64	215.25	363,717
I+50	Interim + 50,000	220	99,589

In each case it was assumed that Lake Jim Chapman was operating at the same conditions as run C-1, which consists of current operating conditions and a demand equal to its maximum yield. Operational releases and spills from Lake Jim Chapman were added to the inflows after diversion by intervening water rights. No water is passed downstream from Lake Jim Chapman to meet demand in Lake Wright Patman even though Lake Wright Patman has the senior water right.

4.2.1 Interim Rule Curve

The current operational rules for Lake Wright Patman, known as the *interim curve*, are illustrated by the red, dashed blue lines and dashed black lines in Figure 4-2. This curve and other operating rules incorporated in the model are from the September 1974 *Wright Patman Lake Master Regulation Manual Appendix I*[3]. Under these rules, the reservoir has a seasonally varying conservation storage pool and variable low-flow releases. The red line is the top of conservation storage. The reservoir has a constant top of conservation storage of 220.6 feet NVGD (122,822 acre-feet of storage) from the beginning of November to the beginning of April. After April 1, the top of conservation

Figure 4-2
Operating Rule Curves for Lake Wright Patman



storage rises to a maximum of 227.5 feet NVGD (308,190 acre-feet of storage) by the beginning of June. After June 1, the top of conservation storage is gradually reduced to 225.0 feet NVGD (231,540 acre-feet) at the beginning of October. From there, the top of conservation storage falls to 221.2 feet NVGD on November 1. After November 1, the top of conservation is 220.6 feet.

The dashed blue and black lines in Figure 4-2 define a transition zone for variable low-flow releases. From the beginning of November until mid-May, if the reservoir water surface elevation is between 220.0 feet and below conservation storage (the red line), a minimum of 10 cfs and a maximum of 96 cfs are released from the reservoir. From mid-May to the beginning of November, if the reservoir elevation is above the dashed blue line and below conservation storage, a constant release of 96 cfs is maintained. If the reservoir is below the dashed blue line but above the dashed black line, a release from 10 cfs to 96 cfs is made. Below the dashed black line, the required release is 10 cfs.

The Lake Wright Patman regulation manual does not specify criteria for setting the release rate between 10 cfs and 96 cfs in the zone below the dashed blue line and above the dashed black line. It is likely that the low-flow releases serve to maintain water quality in the Sulphur River below Wright Patman Dam, but the regulation manual does not give criteria for setting flow levels. Under normal conditions the Corps is releasing more than 96 cfs from May through November in order to follow the descending top of conservation curve, so setting release levels is usually not an issue. For this study, we have assumed that Lake Wright Patman would be operating at or near its full yield, so we have assumed a 10 cfs release below the dashed blue line to maintain reliable water supply.

Current Corps operating procedures maintain a minimum elevation of 220.0 feet NVGD, and the contracts between the Corps and the City of Texarkana grant water from storage above elevation 220.0 feet NVGD. Run I-1 uses only the Lake Wright Patman storage above 220 feet, resulting in a yield of 8,974 acre-feet per year. This amount is considerably less than the current contracted amount of 108,700 acre-feet per year.

With the permission of the Corps, the Texarkana contracts allow withdrawal from storage below 220.0 feet during extended dry periods. Run I-2 uses a minimum elevation of

217.5, midway between the top of the sediment pool (assumed to be 215.25 feet) and 220.0 feet. Run I-2 gives a yield of 104,397 feet, which is slightly less than the contractual amount of for the City of Texarkana. A slightly lower level would probably achieve sufficient yield to meet the Texarkana contract. However, the yield is well below the 180,000 acre-feet per year diversion granted by the State of Texas. Run I-2 goes below 220.0 feet 15 times during the 62-year simulation period. Run I-3 uses all conservation storage above the top of sediment pool (assumed to be 215.25 feet) for water supply. Run I-3 gives a yield of 154,205 acre-feet per year and goes below elevation 220.0 feet 27 times. This yield is more than the current contracted amount, but less than the full diversion allowed by the water right granted by the State of Texas.

More detailed information on these runs may be found in Appendices E and G.

4.2.2 Ultimate Rule Curve

Contracts DACW29-68-A-0103 and DACW29-69-C-0019 between the Corps and the City of Texarkana specify another conservation rule curve for Lake Wright Patman that was to be implemented with the completion of Lake Jim Chapman upstream. This rule curve is referred to as the *ultimate curve*. The green line in Figure 4-2 is a graphical representation of the curve. The contract specifies constant monthly elevations, resulting in a stair-step type curve. A minimum top of conservation of 224.89 feet is specified from January through March. The top of conservation rises to 228.61 in June and 228.64 in July. The curve then steps down to an elevation of 225.17 in December. A similar curve is specified in the water right for Lake Wright Patman issued by the State of Texas, which specifies the elevations as the maximum conservation during each month[4].

Implementation of the ultimate curve requires reallocation of flood storage in Lake Wright Patman. According to contract DACW29-68-A-0103, 120,000 acre-feet of flood control storage became available for reallocation with the completion of Lake Jim Chapman[5]. Table 4-3 compares the differences in reservoir storage for the interim and ultimate curves. Using the latest volumetric survey of the reservoir, the difference in storage between the ultimate and interim curves on November 1 of each year is 122,570 acre-feet, slightly more than the 120,000 acre-feet of flood storage available for reallocation[6].

Table 4-3
Comparison of Interim and Ultimate Curves for Lake Wright Patman*

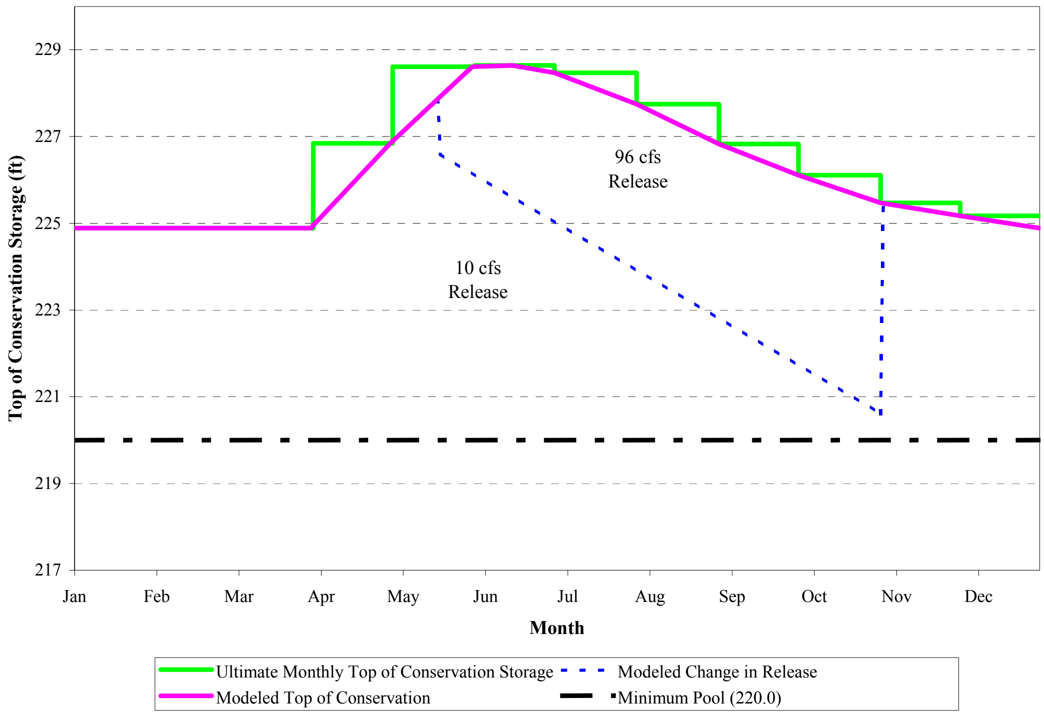
Day	**Interim Curve Elevation** (ft)	**Ultimate Curve Elevation** (ft)	**Interim Curve Total Storage** (ac-ft)	**Ultimate Curve Total Storage** (ac-ft)	**Increase in Total Storage** (ac-ft)	**Interim Curve Storage Above 220 Feet** (ac-ft)	**Ultimate Curve Storage Above 220 Feet** (ac-ft)	**Increase in Storage above 220 Feet** (ac-ft)
Jan-01	220.60	224.89	122,882	228,428	105,546	11,982	117,528	105,546
Mar-31	220.60	224.89	122,882	228,428	105,546	11,982	117,528	105,546
Apr-15	223.00	225.87	177,220	257,775	80,555	66,320	146,875	80,555
Apr-20	223.70	226.19	195,441	267,557	72,116	84,541	156,657	72,116
Apr-25	224.33	226.52	212,586	277,339	64,753	101,686	166,439	64,753
Apr-30	224.90	226.84	228,711	287,121	58,410	117,811	176,221	58,410
May-05	225.45	227.13	244,860	296,421	51,561	133,960	185,521	51,561
May-10	225.92	227.41	258,772	305,721	46,949	147,872	194,821	46,949
May-15	226.38	227.70	272,893	315,021	42,128	161,993	204,121	42,128
May-18	226.60	227.87	279,698	320,601	40,903	168,798	209,701	40,903
May-22	226.90	228.10	288,977	328,041	39,064	178,077	217,141	39,064
May-27	227.22	228.38	299,163	337,342	38,179	188,263	226,442	38,179
May-31	227.50	228.61	308,190	344,782	36,592	197,290	233,882	36,592
Jun-15	227.19	228.64	298,766	345,788	47,023	187,866	234,888	47,023
Jul-01	226.86	228.47	288,713	340,083	51,370	177,813	229,183	51,370
Aug-01	226.23	227.75	269,237	316,250	47,013	158,337	205,350	47,013
Sep-01	225.59	226.83	249,760	286,812	37,052	138,860	175,912	37,052
Sep-30	225.00	226.11	231,540	264,542	33,002	120,640	153,642	33,002
Oct-31	221.20	225.49	135,296	246,049	110,753	24,396	135,149	110,753
Nov-01	220.60	225.47	122,882	245,452	**122,570**	11,982	134,552	122,570
Dec-01	220.60	225.17	122,882	236,572	113,690	11,982	125,672	113,690
Dec-31	220.60	224.89	122,882	228,428	105,546	11,982	117,528	105,546

* Table based on 1996 Volumetric Survey of Lake Wright Patman[6]

Although the ultimate curve has been authorized, it is subject to the processes and procedures defined in the National Environmental Policy Act of 1970 (NEPA) and by the Council on Environmental Quality, the part of the Executive Branch of the Federal Government that oversees the NEPA process. Reallocation will most likely require an Environmental Assessment to be completed before the reallocation of flood storage can be implemented. If reallocation is shown to have significant environmental impacts, a detailed Environmental Impact Statement will be required.

Because the ultimate rule curve is only referenced by month it is uncertain how it would actually be implemented. It is likely that the Corps would implement a smoothly varying curve similar to the interim curve. For this study we developed a smoothly varying curve that never exceeds the maximum conservation storage in any month. This curve is illustrated in Figure 4-3.

Figure 4-3
Ultimate Rule Curve as Modeled



Neither the Texarkana contracts nor the reservoir control manual specify low-flow release rates. Because the precise rationale for these releases is unknown, low-flow release rules similar to those used to model the interim curve were retained for the ultimate curve (see Figure 4-3). These rules call for a minimum low-flow release of 10 cfs and a maximum low-flow release of 96 cfs.

Runs U-1 through U-3a simulate the operation of Lake Wright Patman with the ultimate rule curve. Run U-1 uses only the conservation storage above 220.0 feet, resulting in a yield of 184,591 acre-feet per year. Run U-2 uses a minimum elevation of 217.5 feet, resulting in a yield of 255,194 acre-feet per year. Run U-3 uses the entire conservation storage down to the top of the sediment storage (assumed to be 215.25 feet), giving a yield of 301,580 acre-feet per year. Run U-3a is similar to run U-3 except that it uses the stair-step curve specified in the Texarkana contract, resulting in a yield of 301,450 acre-feet per year. Adoption of the smooth curve has little impact on reservoir yield. All of these runs represent a substantial gain in yield over the interim curve. More detailed information on these runs may be found in Appendices E and G.

As illustrated by run U-1, when using the ultimate curve Lake Wright Patman is capable of supplying its full contractual rights as well as the full diversion granted by the State of Texas water right without going below elevation 220.0 feet. Additional yield of almost 117,000 acre-feet per year may be gained by using all or part of the conservation storage below 220 feet without significant impact on reservoir elevations. In Run U-3, full use of conservation storage, the simulation goes below 220 feet 6 times during the 62-year simulation period. Run U-2, which has a minimum elevation of 217.5 feet, goes below 220 feet 4 times during the simulation.

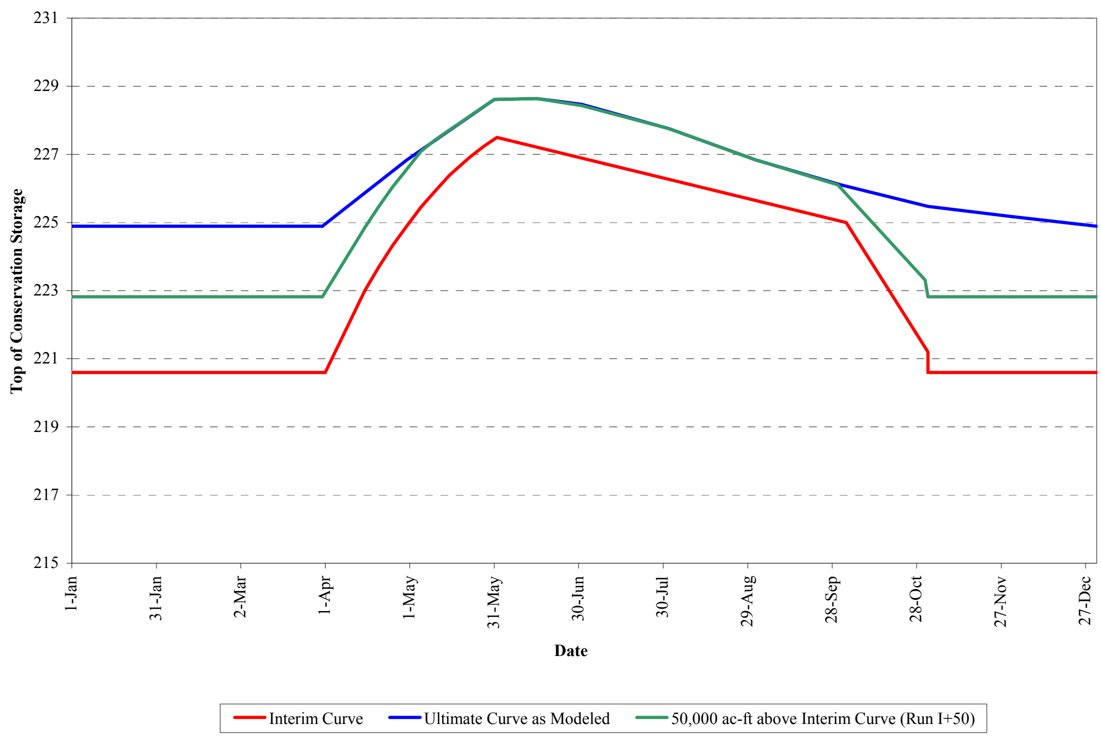
4.2.3 Flat Conservation Storage

Runs F21-1 through F28-2 determine the stand-alone yield of Lake Wright Patman with a constant conservation storage varying between 223.0 feet and 228.64 feet NVGD, the maximum storage in the ultimate curve. These elevations correspond to a conservation storage of 177,220 and 345,788 acre-feet, respectively. As with the runs using the ultimate curve, low-flow release rules similar to the current rules were retained for all runs. Runs F23-1 through F28-1 have a minimum elevation of 220.0 feet NVGD while F23-2 through F28-2 allow full use of conservation storage down to 215.25 feet. With a minimum storage of 220.0 feet, yields range from no reliable yield with a flat pool at 223.0 feet to 275,313 acre-feet per year with a flat pool at 228.64 feet. Using all of the conservation storage to 215.25 feet, yields range from 163,331 acre-feet per year at 223.0 feet to 363,717 acre-feet per year with a flat pool at 228.64 feet. Results are summarized in Table 4-2. Additional information may be found in Appendices E and G.

4.2.4 50,000 Acre-Feet of Flood Storage Reallocation

The Corps has the authority to reallocate up to 50,000 acre-feet of reservoir storage in any of their reservoirs. Reallocation of more than 50,000 acre-feet requires Congressional authorization. Run I+50 is based on a Lake Wright Patman operation curve that has a maximum of 50,000 acre-feet of additional conservation storage above the interim operation curve. The curve is limited to the maximum elevation of the ultimate curve of 228.64 feet NVGD. Figure 4-4 is an illustration of the operational curve compared to the interim and ultimate curves. As with other runs, the low-flow release rules currently in use were retained in this scenario. A minimum allowable elevation of 220.0 feet was assumed in Lake Wright Patman. Using these assumptions, the yield of Lake Wright Patman is 99,589 acre-feet per year.

Figure 4-4
Comparison of Lake Wright Patman Operation Curves
Interim, Ultimate and with 50,000 Acre-Feet of Reallocation

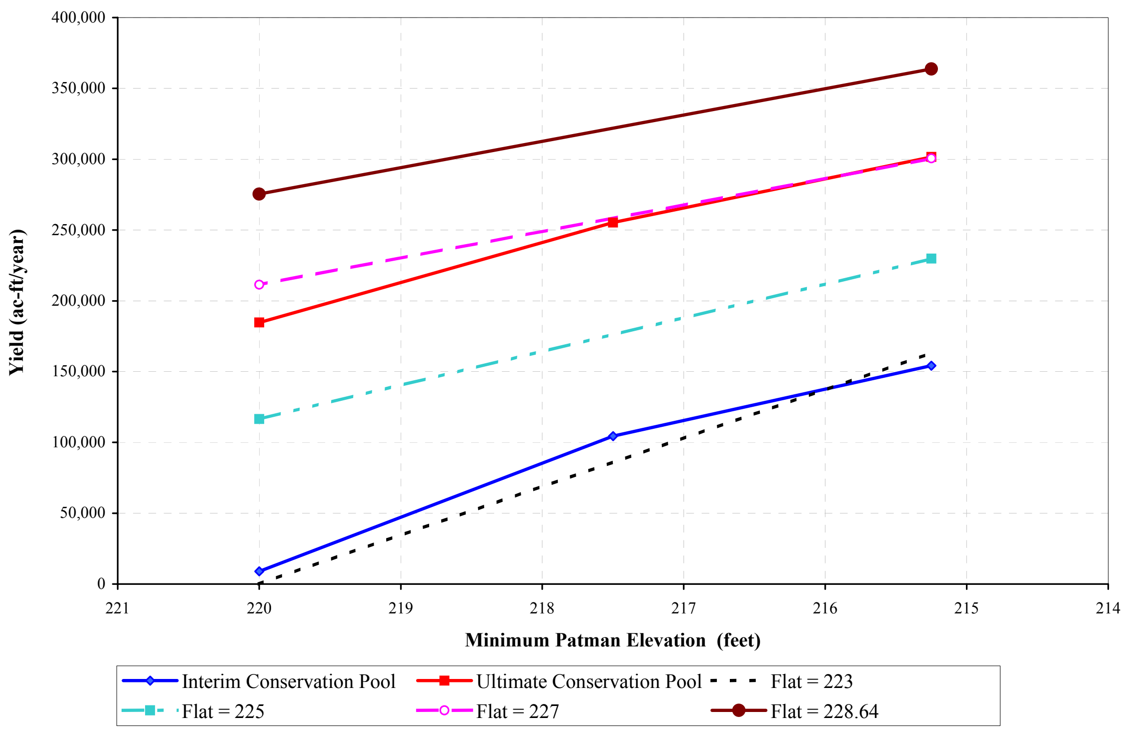


4.2.5 Comparison of Lake Wright Patman Stand-Alone Yields

Results of the stand-alone yield runs for Lake Wright Patman are summarized in Table 4-2. A graphical comparison of the total yield of the two reservoirs may be found in Figure 4-5. Under current operating conditions (interim rule curve), the maximum stand-alone yield of Lake Wright Patman is 154,205 acre-feet per year if full conservation storage down to 215.25 feet is used (run I-3). Implementation of the ultimate rule curve increases the yield of the reservoir to 184,591 acre-feet per year with a minimum Lake

Wright Patman elevation of 220.0 (run U-1). Implementing the ultimate curve with full use of Lake Wright Patman conservation storage results in a stand-alone yield of 301,580 acre-feet per year (run U-3) without substantially affecting the frequency of low reservoir elevations in Lake Wright Patman. The maximum stand-alone yield available from the reservoir is 363,717 acre-feet from a flat top of conservation storage at elevation 228.64 feet and making full use of conservation storage (run F28-2).

Figure 4-5
Comparison of Stand-Alone Yields for Lake Wright Patman



4.3 Impacts at the White Oak Creek WMA

For this study, flows were estimated at the U.S. Highway 67 bridge in the White Oak Creek WMA to evaluate potential impacts on the WMA. A USGS stream gage, the Sulphur River near Darden, operated at the bridge from 1923 to 1956, before the construction of either Lake Wright Patman or Lake Jim Chapman. The gage flows represent an essentially unregulated condition at this location. When comparing flows at this location with Lake Jim Chapman operating using current policies (run C-1), extremely low flows are less frequent than the historical flows because of the 5 cfs constant release from Lake Jim Chapman. All other flow ranges in the model are in the same range as the historical flows. Additional information may be found in Appendices E and G.

Although the range of flows is similar to historical conditions prior to current regulation in the basin, the water surface elevation at this location varies with the assumed conservation storage at Lake Wright Patman. Water surface elevations were determined based on a rating table derived from HEC-2 models provided by the Corps. The rating table may be found in Appendix D.

Plate 1 (located inside the back cover of this report) is a contour map of the White Oak Creek WMA based on USGS topographic maps. Based on this map, water surface elevations above 230 feet roughly correspond to out-of-banks conditions in the lower portion of the WMA. Under current conditions, as represented by the interim curve run I-3, the river is out-of-banks approximately 23% of the time. With higher downstream reservoir elevations in Lake Wright Patman due to implementation of either the ultimate curve or constant conservation storage at 228.64, out-of-bank conditions occur with about the same frequency (22-26%) as they do with the interim curve.

Under current conditions[a], the water surface elevation exceeds elevation 242.0 feet, the lowest control structure in the WMA wetlands, only about 3% of the time. Implementation of alternative operating policies in Lake Wright Patman increases the frequency above 242 feet by about 1%.

For in-bank conditions, implementation of alternative operating policies is expected to increase the amount of water in the channel in the lower portion of the WMA. According to information provided by Texas Parks and Wildlife Department, this would be beneficial to wildlife management operations[2]. However, there may be some negative impacts from raising the water table in the area. Additional studies will be needed to evaluate the impact of higher in-channel flows on the water table and the potential for

---

[a] Current conditions assume full use of Lake Jim Chapman conservation storage down to elevation 215.25 feet NVGD

harm to natural resources of a raised water table. Additional information on inundation frequency is available in Appendix H Tables H.2-15 through H.2-28.

[1] U.S. Army Corps of Engineers Fort Worth District, *Jim Chapman Lake Cooper Dam Water Control Manual Chapter 7*, June 1999.

[2] John C. Jones, Texas Parks and Wildlife Department, *Memorandum on Sulphur River Management Strategy*, July 30, 2002.

[3] U.S. Army Corps of Engineers New Orleans District, *Wright Patman Appendix I Master Reservoir Regulation Manual*, September 1974.

[4] Texas Commission for Environmental Quality, Certificate of Adjudication 03-4836, issued to the City of Texarkana.

[5] Contract DACW29-68-A-103, Between the United States of America and the City of Texarkana for Municipal and Industrial Water Supply Storage Space in Texarkana Reservoir, April 16, 1968.

[6] Texas Water Development Board, Volumetric Survey of Wright Patman Lake, May 1997.

5.0 System Operation

A major objective of this study is an evaluation of the potential of operating Lake Jim Chapman and Lake Wright Patman in a coordinated way to increase yield, also known as *system operation*. System operation of two or more reservoirs may increase the yield above independent operation if the critical drought period that defines the yield of one reservoir is significantly different than the critical drought period of the other reservoir. The *critical drought* is the critical period of low inflow that determines reservoir yield. More formally, it is an extended period of low flow that begins when the reservoir is full and contains the smallest reservoir storage in the period studied using a constant annual demand.

In the case of these two reservoirs, Lake Jim Chapman has a larger ratio of storage to drainage area than Lake Wright Patman. Lake Jim Chapman has 653 acre-feet of conservation storage per square mile of drainage area, while Lake Wright Patman has a maximum of 93 acre-feet of conservation storage per square mile of drainage area under current operation rules. Because Lake Jim Chapman can store a larger portion of the runoff that occurs above the reservoir, it has a critical drought period extending from May 1953 to January of 1957, a period of 1,324 days. Although Lake Wright Patman is a larger reservoir, it has less storage relative to the runoff that occurs above the reservoir and fills frequently, even during drought periods. Under the current operating criteria (the interim curve), Lake Wright Patman's critical period is from April 1978 through November 1978, a period of 219 days. During Lake Jim Chapman's critical period, Lake Wright Patman is above conservation storage 4 times. As a result, some additional yield could be gained if some of the water from flood storage in Lake Wright Patman is used to meet demands at Lake Jim Chapman.

5.1 Implementation of System Operation

The model bases system operation on a series of user-defined storage zones in each reservoir. These storage zones may vary by time of year and can include both conservation and controlled flood storage. Pumping from Lake Wright Patman to Lake Jim Chapman is determined by the combination of zones in the reservoirs. Each zone combination is assigned a percentage of the assumed maximum pumping capacity.

Figure 5-1 is an example of the zone system using the ultimate rule curve for Lake Wright Patman and current operations at Lake Jim Chapman (run U-1). Using this scenario, if at the beginning of June, Lake Wright Patman is at elevation 228.0 feet and Lake Jim Chapman is at elevation 438.0 feet (both reservoirs in zone 2), pumping from Lake Wright Patman is set to 50% of the maximum pumping rate.

For each system operation scenario, the zones in both reservoirs and maximum pumping rates from Lake Wright Patman to Lake Jim Chapman were systematically varied to find combinations that resulted in gains in yield. Maximum pumping rates were varied from 60 to 300 mgd. Appendix G contains specific information regarding the zones used for the system operation runs conducted for this study.

Seven variations of system operation are discussed in this section:

- System run I-3 - The Lake Wright Patman interim curve using full conservation storage (215.25. feet NVGD) and Lake Jim Chapman using current operation rules
- System run U-1 - The Lake Wright Patman ultimate curve using storage above 220.0 feet NVGD and Lake Jim Chapman using current operation rules
- System run U-3 - The Lake Wright Patman ultimate curve using full conservation storage and Lake Jim Chapman using current operation rules
- System run F28-1 – A flat conservation pool at 228.64 feet for Lake Wright Patman using storage above 220.0 feet and Lake Jim Chapman using current operation rules
- System run F28-2 – A flat conservation pool at 228.64 feet for Lake Wright Patman using full conservation storage and Lake Jim Chapman using current operation rules
- System run I+50 - The Lake Wright Patman interim curve with an additional 50,000 acre-feet of conservation storage, limited to storage above 220.0 feet NVGD and Lake Jim Chapman using current operation rules
- System run C-2 - A flat conservation pool at 228.64 feet for Lake Wright Patman using storage above 220.0 feet and Lake Jim Chapman using TPWD wildlife management goals

Other combinations were evaluated as well and may be found in Appendix G.

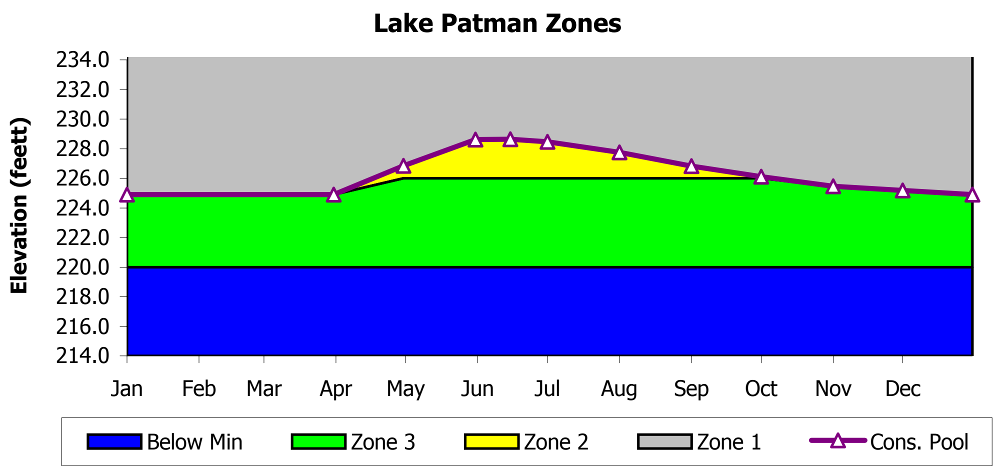
The naming convention used for these scenarios is similar to the stand-alone runs presented in Chapter 4. For example, system run U-3 200 uses the same reservoir

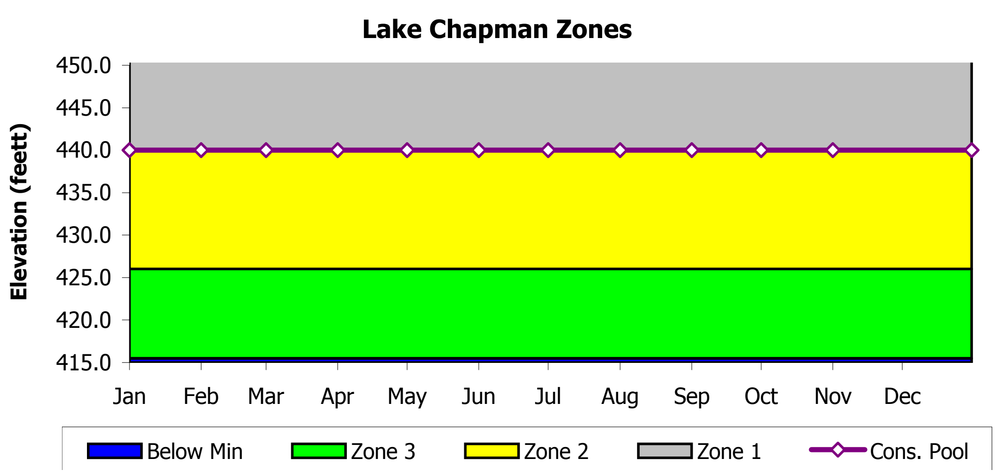
Figure 5-1
Example of Reservoir Storage Zones

Run
U-1

Pumping Rates

		Patman		
		1	**2**	**3**
Chapman	**1**	0	0	0
	2	MAX	0.5 MAX	0
	3	MAX	100 MGD	100 MGD





operating rules as stand-alone run I-3 but assumes that the two reservoirs are operated as a system, with a maximum pumping capacity of 200 mgd from Lake Wright Patman to Lake Jim Chapman. The zones illustrated in Figure 5-1 govern pumping.

If water is pumped from the controlled flood pool in Lake Wright Patman, the model assumes that downstream releases would be reduced by the amount being pumped out of the reservoir. For example, if controlled flood operation from Lake Wright Patman calls for a release of 5,000 cfs and at the same time water is being pumped from Lake Wright Patman to Lake Jim Chapman at a rate of 200 mgd (310 cfs), flood pool releases are reduced to 4,690 cfs. However, the downstream release may never be less than the minimum release (either 10 cfs or 96 cfs, see Section 4.2).

5.2 System Operation Using Interim Curve

The interim operating curve is the current operation policy for Lake Wright Patman. (See Section 4.2.1 for more information.) System run I-3 uses the interim curve in Lake Wright Patman and a minimum conservation elevation of 215.25 feet. An alternative using a minimum conservation elevation of 220.0 feet in Lake Wright Patman (corresponding to stand-alone run I-1) was not used because there is less than 9,000 acre-feet of yield from Lake Wright Patman. Run I-3 assumes that pumping from Lake Wright Patman occurs any time that Lake Wright Patman is above its conservation elevation (in the flood pool) and there is empty storage in Lake Jim Chapman. Results for system run I-3 may be found in Table 5-1. Note that a pumping rate of 0 mgd is identical to stand-alone operation.

5.2.1 System Yield

With a pipeline capacity of 60 mgd, the increase in yield for system run I-3 is 13,255 acre-feet per year, an increase of about 5%. With a pipeline capacity of 300 mgd, the increase in system yield is 52,700 acre-feet per year, an increase of about 19%. Larger pumping rates were evaluated but discarded as impractical because of the high cost of building pipelines of capacities greater than 300 mgd.

Table 5-1
System Run I-3 Yields: Interim Curve in Lake Wright Patman with full use of Conservation Storage

Pumping Rate (mgd)	**Lake Jim Chapman Diversion** (ac-ft/yr)*	**Lake Wright Patman Diversion** (ac-ft/yr)	**Total Yield** (ac-ft/yr)	**Increase Due to System Operation** (ac-ft/yr)	**Percent Increase**
0	128,600	154,205	282,805	-	-
60	141,855	154,205	296,060	13,255	5%
120	151,861	154,205	306,066	23,261	8%
200	164,597	154,205	318,802	35,997	13%
300	181,300	154,205	335,505	52,700	19%

* Currently Lake Jim Chapman water rights limit diversions to 146, 520 acre-feet per year

Table 5-2 summarizes statistics for pumping from Lake Wright Patman to Lake Jim Chapman for system run I-3. Note that the increase in yield due to system operation is a little more than half of the average amount of water pumped each year. The pipeline would be in operation about 30% to 40% of the time, depending upon the maximum pumping rate.

Table 5-2
System Run I-3: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		**Maximum Pumping Rate**			
		60 MGD	**120 MGD**	**200 MGD**	**300 MGD**
Average Annual Pumping	ac-ft	24,689	48,217	73,200	97,440
	mgd	22	43	65	87
Maximum Annual Pumping	ac-ft	42,957	86,751	128,765	185,147
	mgd	38	77	115	165
Minimum Annual Pumping	ac-ft	4,740	10,004	16,803	25,390
	mgd	4.2	8.9	15	23
Average flow in days of pumping (mgd)	mgd	58	112	182	261
Average number of days of pumping/year		139	140	131	122
Average number of days/year when pumping was at maximum rate		129	124	112	97

5.2.2 Impacts

Implementation of system operation in system run I-3 has practically no impact on Lake Wright Patman elevations. Elevations in Lake Wright Patman are practically identical in all cases because 1) pumping only occurs from the flood pool and 2) downstream releases from the flood pool are reduced by the amount being pumped from the flood pool. As a result practically the same amount of water is taken from Lake Wright Patman with system operation as with stand-alone operation.

With system operation the elevations in Lake Jim Chapman were slightly higher most of the time. Lake Jim Chapman is above conservation storage about 17% of the time at the 60 mgd pumping rate, which is practically identical to the stand-alone operation. The frequency of elevations above conservation storage increases to about 23% of the time at the 300 mgd pumping rate. However, an inspection of the range of elevations at or near conservation storage shows that most of the increase in frequency above conservation storage is confined to elevations that are within 0.2 feet of conservation storage. Given the limitations of this analysis, this increase in elevations above conservation storage may not be significant. The frequency of extreme flood events is comparable with and without system operation. The reservoir goes above the controlled flood pool 4 times with and without system operation. With system operations, elevations within the top 10 feet of storage are generally higher with system operation. Moderately low elevations occur less frequently with little change in extremely low elevations during critical drought periods. More information can be found in Appendices F and G.

Implementation of system operation in run I-3 has little impact on flows or frequency of inundation at the Highway 67 bridge in the White Oak Creek WMA. The frequency of inundation at the bridge is very similar in all variations of system run I-3, primarily because of the similar elevations at Lake Wright Patman for all of the runs. Appendix H contains additional information on flow and inundation frequency at the Highway 67 bridge for run I-3 and other system operation runs.

Implementation of system operation does have an impact on downstream releases from Lake Wright Patman. This is primarily because the additional demand on the system reduces the quantity of water released downstream to maintain Lake Wright Patman at conservation storage. For example, assume that in the month of February a 200 cfs release is required to maintain the reservoir at conservation storage without system operation. If we assume that there is a 120 mgd pipeline, about 186 cfs of that release is available for pumping to Lake Chapman, thereby reducing the release required to maintain conservation storage to 14 cfs. System operation does not significantly impact the occurrence of higher releases. More information on downstream releases may be found in Appendices F and G.

5.3 System Operation Using Ultimate Curve

Several operating scenarios were evaluated using the ultimate conservation storage curve in Lake Wright Patman. The two scenarios presented in this report are system runs U-1 and U-3, which use the same operating criteria as the stand-alone runs U-1 and U-3 in Chapter 4. Run U-1 uses the ultimate curve in Lake Wright Patman with a minimum elevation of 220.0 feet NGVD. Run U-3 uses the entire conservation storage of Lake Wright Patman, with the minimum elevation at the top of sediment storage (215.25 feet NVGD). The runs used pumping rates from 60 mgd to 300 mgd. Larger pumping rates were considered but discarded as impractical. In each case, reservoir zones were adjusted to maximize yield. See Appendix G for information on the reservoir zones used in runs U-1 and U-3.

5.3.1 System Yield

Table 5-3 compares system runs U-1 and U-3. Note that a 0 mgd pumping rate is identical to the stand-alone yield of the two reservoirs. Using a minimum elevation of 220.0 feet in Lake Wright Patman system gains range from 32,500 acre-feet per year at 60 mgd maximum pumping to 73,909 acre-feet per year at 300 mgd maximum pumping, gains of 10% to 24%, respectively. Using the entire conservation storage of Lake Wright Patman, the increase in system yield ranges from 25,000 acre-feet per year at 60 mgd to 66,035 acre-feet per year at 300 mgd, increases of 6% to 15%, respectively. Although the increase in yield using the full conservation storage is less than using the 220.0-foot minimum, the overall yield of the system is about 110,000 acre-feet per year higher than when limited to conservation storage above 220.0 feet.

Table 5-4 summarizes pumping for system run U-1, and Table 5-5 summarizes pumping for system run U-3. In Run U-1 pumping would range from 58% of the time at 60 mgd to 44% of the time at 300 mgd. In run U-3, pumping ranges from 20% of the time at 60 mgd to 15% of the time at 300 mgd. Run U-3 has several years where little or no pumping occurs at all.

Table 5-3
System Runs U-1 and U-3: Ultimate Storage in Lake Wright Patman

Run	Pumping Rate (mgd)	Lake Jim Chapman Diversion (ac-ft/yr)	Lake Wright Patman Diversion (ac-ft/yr)	Total Yield (ac-ft/yr)	Increase Due to System Operation (ac-ft/yr)	Percent Increase
U-1	0	128,600	184,591	313,191	-	-
	60	161,100	184,000	345,100	32,500	10%
	120	177,200	183,600	360,800	47,609	15%
	200	193,000	183,200	376,200	63,009	20%
	300	203,900	183,200	387,100	73,909	24%
U-3	0	128,600	301,580	430,180	-	-
	60	153,600	301,580	455,180	25,000	6%
	120	172,400	301,580	473,980	43,800	9%
	200	186,600	301,580	488,180	58,000	13%
	300	202,600	293,615	496,215	66,035	15%

Table 5-4
System Run U-1: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		Maximum Pumping Rate			
		60 MGD	120 MGD	200 MGD	300 MGD
Average Annual Pumping	ac-ft	33,646	62,491	93,823	119,163
	mgd	30	56	84	106
Maximum Annual Pumping	ac-ft	56,641	106,099	155,956	201,085
	mgd	51	95	139	179
Minimum Annual Pumping	ac-ft	10,223	17,683	29,472	35,919
	mgd	9	16	26	32
Average flow in days of pumping (mgd)	mgd	52	101	164	240
Average number of days of pumping/year		213	202	187	162
Average number of days/year when pumping was at maximum rate		153	135	119	98

Table 5-5
System Run U-3: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		Maximum Pumping Rate			
		60 MGD	120 MGD	200 MGD	300 MGD
Average Annual Pumping	ac-ft	13,360	26,269	37,830	50,031
	mgd	12	23	34	45
Maximum Annual Pumping	ac-ft	51,576	88,784	124,028	147,360
	mgd	46	79	111	132
Minimum Annual Pumping	ac-ft	0	0	0	0
	mgd	0	0	0	0
Average flow in days of pumping (mgd)	mgd	60	120	200	300
Average number of days of pumping/year		73	71	62	54
Average number of days/year when pumping was at max rate		73	71	62	54

5.3.2 Impacts

In system run U-1, the range of elevations in Lake Jim Chapman are similar at all pumping levels and are similar to the stand-alone yield runs (no pumping scenario). The percentage of time above conservation storage ranges from 15% of the time at 120 mgd to 21% of the time at 300 mgd. An inspection of the frequency of ranges near conservation storage shows that the frequency of elevations close to conservation storage is about the same for all runs. Given the limitations of the analysis, the increase in frequency above conservation storage is probably not significant. Increased pumping capacity and system yield in run U-1 tends to increase the drawdown of Lake Jim Chapman during dry periods. Increased pumping from Lake Wright Patman does not appear to significantly affect elevations except during dry periods, when the reservoir tends to be drawn down more than stand-alone operation. This is primarily because system runs U-1 allow pumping from conservation storage in Lake Wright Patman. However, the majority of the time (about 90%), there is little or no difference in Lake Wright Patman elevations with and without system operation.

In system run U-3, there is a noticeable impact on Lake Jim Chapman elevations during dry periods. This is most likely because more water is being used at Lake Wright Patman than under run U-1, making less water available for pumping to Lake Jim Chapman.

Taking less water from the system could lessen the impact on Lake Jim Chapman elevations. Implementation of system operation in Run U-3 reduces the frequency of Lake Jim Chapman elevations above conservation storage and decreases the number of times that the reservoir goes above controlled flood storage. However, an inspection of the frequency of elevations near or slightly above conservation storage shows little significant difference between the frequencies of elevations above conservation storage. Given the limitations of the analysis, the differences are probably not significant. As with run U-1, reservoir levels are lower in Lake Wright Patman during dry periods. Higher elevations are very similar at all pumping rates. In system run U-3, Lake Wright Patman goes below 220 feet from 6 to 10 times over the 62-year simulation period. However, the percentage of time the reservoir is below 220 feet is about the same at all pumping rates. More information may be found in Appendices F and G.

For both runs U-1 and U-3, implementation of system operation slightly increases the frequency of elevations less than 225 feet at the Highway 67 bridge in the White Oak Creek WMA. Otherwise, system runs U-1 and U-3 have little impact on flows frequency of inundation. Appendix H contains additional information on flow and inundation frequency.

System runs U-1 and U-3 show a reduction in the frequency of downstream releases between 96 cfs and 1,000 with increased pumping capacity. System run U-1, which uses only conservation storage above elevation 220.0 feet, shows a greater reduction in downstream releases than run U-3, which uses the entire conservation storage. Under stand-alone operation for run U-1 a great deal of water is released downstream to maintain the reservoir at conservation storage. With system operation, pumping to Lake Jim Chapman decreases the need for frequent releases from the reservoir, causing a reduction in downstream releases. System operation does not significantly impact the occurrence of higher releases (above 1,000 cfs) in either run. More information may be found in Appendices F and G.

5.4 System Operation Using Flat Conservation

System runs F28-1 and F28-2 evaluate system operation using a flat conservation pool in Lake Wright Patman of 228.64 feet NVGD, which is the same as the maximum elevation as the ultimate curve. System run F28-1 uses only the storage in Lake Wright Patman above 220.0 feet while system run F28-2 uses the entire conservation storage of Lake Wright Patman. (Runs using a flat conservation pool of 225.0 feet were made as well and may be found in Appendix G.) Reservoir zones were manipulated to maximize yield on these runs. Illustrations of the zones may be found in Appendix G.

5.4.1 System Yield

Table 5-6 summarizes the yield for system runs F28-1 and F28-2 using pumping rates of 60, 120, 200 and 300 mgd. A pumping rate of 0 mgd is identical to stand-alone operation of the two reservoirs. Using only the portion of Lake Wright Patman storage above 220.0 feet (system run F28-1) gives a system increase ranging from 24,619 acre-feet per year at 60 mgd to 84,532 acre-feet per year at 300 mgd, increases of 6% and 21% respectively. Using the full conservation storage at Lake Wright Patman (system run F28-2) gives an increase in yield ranging from 27,500 acre-feet at 60 mgd to 108,939 acre-feet per year at 300 mgd, increases of 6% to 22%, respectively.

Table 5-6
System Runs F28-1 and F28-2: Flat Conservation Pool in Lake Wright Patman

Run	**Pumping Rate** (mgd)	**Lake Jim Chapman Diversion** (ac-ft/yr)	**Lake Wright Patman Diversion** (ac-ft/yr)	**Total Yield** (ac-ft/yr)	**Increase Due to System Operation** (ac-ft/yr)	**Percent Increase**
F28-1	0	128,600	275,313	403,913	-	-
	60	153,219	275,313	428,532	24,619	6%
	120	179,986	275,313	455,299	51,386	13%
	200	203,600	275,313	478,913	75,000	19%
	300	216,600	275,313	488,445	84,532	21%
F28-2	0	128,600	363,717	492,317	-	-
	60	156,100	363,717	519,817	27,500	6%
	120	180,500	363,717	544,217	51,800	11%
	200	212,100	363,717	575,817	83,500	17%
	300	237,539	363,717	601,256	108,939	22%

Tables 5-7 and 5-8 summarize pumping statistics for system runs F28-1 and F28-2. Run F28-1 shows, on average, pumping from Lake Wright Patman to Lake Jim Chapman ranging from a high of 20% of the time at 120 mgd to 16% of the time at 300 mgd. Run

F28-2 pumping frequency ranges from 22% of the time at 200 mgd to 20% of the time for both 60 and 300 mgd. As with system run U-3, run F28-2 has several years where little or no pumping occurs.

Table 5-7
System Run F28-1: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		Maximum Pumping Rate			
		60 MGD	120 MGD	200 MGD	300 MGD
Average Annual Pumping	Ac-ft	11,881	26,299	42,247	53,715
	Mgd	11	23	38	48
Maximum Annual Pumping	Ac-ft	51,023	90,258	127,712	156,570
	Mgd	46	81	114	140
Minimum Annual Pumping	Ac-ft	0	0	0	0
	Mgd	0	0	0	0
Average flow in days of pumping (mgd)	Mgd	60	120	200	300
Average number of days of pumping/year		65	71	69	58
Average number of days/year when pumping was at max rate		65	71	69	58

Table 5-8
System Run F28-2: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		Maximum Pumping Rate			
		60 MGD	120 MGD	200 MGD	300 MGD
Average Annual Pumping	Ac-ft	13,542	29,216	49,675	68,228
	mgd	12	26	44	61
Maximum Annual Pumping	Ac-ft	51,392	93,205	143,676	196,173
	mgd	46	83	128	175
Minimum Annual Pumping	Ac-ft	0	0	0	0
	mgd	0	0	0	0
Average flow in days of pumping (mgd)	mgd	60	120	200	300
Average number of days of pumping/year		74	79	81	74
Average number of days/year when pumping was at max rate		74	79	81	74

5.4.2 Impacts

In both system runs F28-1 and F28-2 Lake Jim Chapman elevations are lower as pumping increases from Lake Wright Patman. This is due to the increased diversions from Lake Jim Chapman at higher pumping rates. The reservoir is above conservation storage less frequently as well, as are the number of times the reservoir exceeds its controlled flood storage. The impact on reservoir elevations could be somewhat reduced if less water is taken from the system. Elevations are somewhat lower in Lake Wright Patman as well because of pumping to Lake Jim Chapman from conservation storage, but the impacts are not as pronounced as Lake Jim Chapman. More specific information may be found in Appendices F and G.

In these runs implementation of system operation somewhat increases the frequency of elevations less than 227 feet at the Highway 67 bridge in the White Oak Creek WMA. Otherwise, these runs have little impact on flows frequency of inundation. Appendix H contains additional information on flow and inundation frequency.

Downstream releases from Lake Wright Patman at the 96 cfs release rate occurs about 2% less with system operation. Releases between 100 cfs and 1,000 cfs and between 1,000 and 10,000 cfs occur somewhat less frequently as well. Releases at the 10,000 cfs rate (the maximum release rate from Lake Wright Patman) occur with about the same frequency with and without system operation. More information may be found in Appendices F and G.

5.5 System Operation with 50,000 Acre-Feet of Reallocation

System run I+50 is based on a Lake Wright Patman operation curve that has a maximum of 50,000 acre-feet of additional storage above the interim operation curve, limited to a maximum elevation of 228.64 feet NVGD. Figure 4-3 in Chapter 4 is an illustration of the conservation storage curve. The minimum allowable elevation in Lake Wright Patman is assumed to be 220.0 feet. The no pumping scenario is identical to stand-alone run I+50 (see Section 4.2.4).

5.5.1 System Yield

Table 5-9 is a summary of system yield at various pumping rates. Pumping rates were varied from 60 mgd to 300 mgd. At 60 mgd, the increase in system yield is 43,800 acre-feet per year, an increase of about 19%. At 300 mgd the increase in system yield is 130,466 acre-feet per year, an increase of about 57%. The yield of the system with no pumping, which is equivalent to the stand-alone yield of the system, is 228,189 acre-feet per year. The large percent increase in yield under system operation is most likely attributed to the relatively small usable storage in Lake Wright Patman under stand-alone operation. Without system operation, much of the inflow into the reservoir is released downstream to maintain the reservoir at conservation storage. With system operation, pumping from Lake Wright Patman allows access to some of the flow that would otherwise be released downstream.

Table 5-9
Run I+50 Yields: Interim Curve in Lake Wright Patman with 50,000 Acre-Feet of Reallocation

Pumping Rate (mgd)	**Lake Jim Chapman Diversion** (ac-ft/yr)	**Lake Wright Patman Diversion** (ac-ft/yr)	**Total Yield** (ac-ft/yr)	**Increase Due to System Operation** (ac-ft/yr)	**Percent Increase**
0	128,600	99,589	228,189	-	-
60	172,400	99,589	271,989	43,800	19%
120	213,100	99,589	312,689	84,500	37%
200	236,100	99,589	335,689	107,500	47%
300	259,046	99,589	358,635	130,446	57%

Table 5-10 summarizes statistics for pumping from Lake Wright Patman to Lake Jim Chapman under Run I+50. Using these operating criteria, pumping ranges on average from about 63% of the time at 60 mgd to about 52% of the time at 300 mgd.

5.5.2 Impacts

Frequency of Lake Jim Chapman elevations in the flood pool decreases with increasing pumping rates up to 120 mgd, varying from about 17% of the time with no pumping to 14% of the time at 120 mgd. At higher pumping rates, the frequency of elevations in the flood pool increases reaching a maximum of 18% at 300 mgd. The frequency of lower elevations in Lake Jim Chapman shows the greatest change at the 120 mgd pumping rate as well, with the highest frequency of low elevations occurring at that pumping rate. Elevations in Lake Wright Patman between 222.82 feet and 228.64 feet are only slightly lower at higher pumping rates. More information may be found in Appendices F and G.

Table 5-10
Run I+50: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		Maximum Pumping Rate			
		60 MGD	120 MGD	200 MGD	300 MGD
Average Annual Pumping	ac-ft	42,212	84,322	132,703	175,926
	mgd	38	75	118	157
Maximum Annual Pumping	ac-ft	62,075	119,362	190,340	249,591
	mgd	55	107	170	223
Minimum Annual Pumping	ac-ft	17,131	35,735	57,716	80,127
	mgd	15	32	52	72
Average flow in days of pumping	mgd	60	120	200	300
Average number of days of pumping/year		229	229	216	191
Average number of days/year when pumping was at maximum rate		229	229	216	191

There is no discernable impact on water surface elevations of implementation of system operation or pumping rates at the Highway 67 bridge in the White Oak Creek WMA with the implementation of run I+50 system operation scenario.

In the I+50 system runs increased maximum pumping rates have a much greater impact than other scenarios on reducing downstream releases from both conservation and flood storage in Lake Wright Patman with little impact on reservoir elevations in the reservoir. The primary cause of the change in frequency of release is because under these operating rules pumping from Lake Wright Patman to Lake Jim Chapman occurs more frequently than in other runs. Pumping to Lake Jim Chapman is subtracted from the flood pool releases by the model.

5.6 System Operation Using Wildlife Management Criteria

System run C-2 uses the wildlife management operational criteria for Lake Jim Chapman developed by John Jones, Manager of the White Oak Creek Wildlife Management Area for the Texas Parks and Wildlife Department (TPWD)[1]. The Lake Jim Chapman operating criteria provided by TPWD calls for a slow drop in reservoir elevations from mid-January through late April followed by a slight rise in reservoir elevations in mid-summer. Starting in mid-August the reservoir elevation goes through two fairly rapid drops until the beginning of October. The reservoir elevation then rises to current top of conservation storage by the end of the year. Figure 4-1 in Chapter 4 is an illustration of this operating curve. It is assumed that Lake Wright Patman uses a flat conservation pool at elevation 228.64 feet NVGD and uses the full conservation pool down to elevation 215.25 feet NVGD.

5.6.1 System Yield

Table 5-11 compares the operation with wildlife management criteria to system run F28-2, which is the equivalent run using current Lake Jim Chapman operation. The yield of the system without pumping, which is equivalent to the two reservoirs operating independently, is 481,073 acre-feet per year. Using the wildlife management criteria, the stand-alone yield of Lake Jim Chapman is 108,533 acre-feet per year, which is 15.6% less that the yield under current operation (see Section 4.1.2). The stand-alone yield of Lake Wright Patman is a little more than 2% higher than the stand-alone yield of run F28-2. This is because the wildlife management goals increase the amount of water that is released from Lake Jim Chapman. That water is captured in Lake Wright Patman, increasing the stand-alone yield of that reservoir. The combined yield of the two reservoirs is 11,244 acre-feet per year less than if Lake Jim Chapman operated under current conditions.

Table 5-11
Comparison of System Run C-2 Yields (Wildlife Management Operation at Lake Jim Chapman) to System Run F28-2 Yields (Current Lake Jim Chapman Operation)

Maximum Pumping Rate (mgd)	**Run C-2 System Yield** (ac-ft/yr)	**Run F28-2 System Yield** (ac-ft/yr)	**Difference**
0	481,073	492,317	11,244
60	510,173	519,817	9,644
120	536,706	544,217	7,511
200	564,533	575,817	11,284
300	589,233	601,256	12,023

With the implementation of system operation, yield increases range from 29,100 acre-feet per year at the 60 mgd maximum pumping rate to 117,000 acre-feet per year at the 300 mgd maximum pumping rate, increases of 6% and 24%, respectively. As shown in Table 5-12, implementation of the wildlife management goals at Lake Jim Chapman reduces system yield when compared to Run F28-2 by a minimum of 7,500 acre-feet per year at the 120 mgd maximum pumping rate to a maximum of 12,000 acre-feet per year at the 300 mgd maximum pumping rate.

Table 5-12
Run C-2 Yields: Wildlife Management Operation at Lake Jim Chapman

Pumping Rate (mgd)	**Lake Jim Chapman Diversion** (ac-ft/yr)	**Lake Wright Patman Diversion** (ac-ft/yr)	**Total Yield** (ac-ft/yr)	**Increase Due to System Operation** (ac-ft/yr)	**Percent Increase**
0	108,533	372,540	481,073	0	
60	137,633	372,540	510,173	29,100	6%
120	169,706	367,000	536,706	61,173	13%
200	200,533	364,000	564,533	92,000	19%
300	225,533	363,700	589,233	117,000	24%

Table 5-13 summarizes pumping statistics for Run C-2. In this run average pumping ranges from 30% of the time at 300 mgd to 34% of the time at 120 mgd.

Table 5-13
Run C-2: Statistics for Pumping from Lake Wright Patman to Lake Jim Chapman

Statistic		**Maximum Pumping Rate**			
		60 MGD	**120 MGD**	**200 MGD**	**300 MGD**
Average Annual Pumping	Ac-ft	22,045	45,420	73,423	101,548
	mgd	20	41	66	91
Maximum Annual Pumping	Ac-ft	53,971	98,363	161,482	217,356
	mgd	48	88	144	194
Minimum Annual Pumping	Ac-ft	1,842	5,158	8,596	9,210
	mgd	2	5	8	8
Average flow in days of pumping (mgd)	mgd	60	120	200	300
Average Number of days of pumping/year		120	123	120	110
Average number of days/year when pumping was at max rate		120	123	120	110

5.6.2 Impacts

Implementation of system operation results in a decrease of elevations at Lake Jim Chapman above elevation 440.0 feet (current top of conservation) with increased pumping rates. The frequency of lower elevations in Lake Jim Chapman increases with pumping rates as well. Frequency of elevations in the flood pool at Lake Wright Patman is about the same with and without system operation. Frequencies of elevations below 220.0 feet in Lake Wright Patman are about the same at all pumping rates except for the maximum pumping rate of 300 mgd, which increases the occurrence of low elevations. Additional information may be found in Appendices F and G.

Water surface elevations below 225 feet at the Highway 67 bridge in the White Oak Creek WMA are slightly more frequent in the system operation runs. Other elevations are about the same with or without system operation.

The impact on downstream releases is similar to other runs, with release frequencies below the maximum of 10,000 cfs somewhat less than without system operation.

5.7 Interruptible Demand

Several different options for interruptible demand were evaluated as part of the system operation study. Interruptible demand refers to water that is available from the system on a less than reliable basis. Under certain conditions, this demand will be reduced or curtailed. The example presented in this report is based on system run U-1 (Ultimate Lake Wright Patman operation curve with a minimum storage of 220.0 feet) with a 200 mgd maximum pumping rate. Table 5-14 compares the yield of the system without interruptible demand to systems with an interruptible demand of 20,000 acre-feet per year that has a reliability of 95% and an interruptible demand of 100,000 acre-feet per year that has a reliability of 91%. In these runs, interruptible demand is available when Lake Jim Chapman is above 430.0 feet NVGD (10 feet below conservation). Note that use of interruptible demands causes a corresponding reduction in reliable supply from the system.

Table 5-14
Run U-1 Yields with Interruptible Demands
(values in Acre-Feet per Year)

Patman Demand	Reliable Chapman Demand	Inter-ruptible Demand	Reliable Demand from System	Maximum Demand from System	% Days with max demand supplied	Average Demand from Chapman	Average Demand from System
183,200	193,000	0	376,200	376,200	100%	193,000	376,200
182,000	179,100	20,000	361,100	381,100	95%	198,040	380,040
182,000	137,350	100,000	319,350	419,350	91%	228,895	410,895

Use of interruptible demand causes a slight decrease in the frequency of elevations above conservation in Lake Jim Chapman. The greatest impact on elevation is with the higher interruptible demands during dry periods. The frequency of extremely low elevations (below about 426.0 feet) in Lake Jim Chapman is not greatly impacted. There is little change in the elevations of Lake Wright Patman.

There are a great many ways that interruptible demand could be implemented as part of this system, some with greater impacts and some with fewer impacts. The examples given here give a range from a small amount of interruptible demand to a large amount of demand. Before electing to operate with interruptible demand the potential for use of water from such a supply should be evaluated.

5.8 Cost of Transmission Facilities

Implementation of system operation would require the construction of transmission facilities from Lake Wright Patman to Lake Jim Chapman. For conceptual purposes, we have developed cost estimates for a pipeline that originates on the north shore of Lake Wright Patman with an outlet structure on the south end of Lake Jim Chapman near the dam. (See Figure 2-1.) Facilities include an intake structure and pump station at Lake Wright Patman, pipe and appurtenances, a booster pump station with storage tanks, and an outlet structure at Lake Jim Chapman. Costs include pipe installation, right-of-way, environmental and archeological studies associated with the pipeline, and engineering and contingencies at 30% of construction costs. Detailed cost estimates may be found in Appendix I.

Table 5-15 also includes the approximate annual delivery capacity for typical pipeline of these sizes. Most pipeline designs include some reserve capacity so that pumping can be increased during higher demand periods. These calculations assume a 75% delivery factor to account for reserve capacity. Note that the pipelines needed to implement system operation are capable of delivering much more water on a reliable basis than is made available in any of the system operation runs.

The costs in Table 5-15 are strictly for implementation of system operation. Pipelines will have to be constructed under any alternative that assumes water use will be outside the basin. The most likely customers for additional yield from the system are located in the Dallas-Fort Worth metroplex, requiring an additional large pipeline from Lake Jim Chapman to that area. If the same out-of-basin customers use water from reallocation of flood storage in Lake Wright Patman, a pipeline with more capacity, or possibly a parallel pipeline from Lake Wright Patman to Lake Jim Chapman, would be required.

Table 5-15
Cost of Transmission Facilities

System Capacity (mgd)	**Pipe Size** (inches)	**Capital Costs**	**Approximate Delivery Capacity** (ac-ft per year)
60	60	$151,003,000	50,500
120	78	$221,999,000	100,000
200	96	$249,436,000	168,000
300	120	$448,733,000	252,000

5.9 Impact of System Operation on Water Quality

Table 5-16 contains the average concentration of parameters from Lake Jim Chapman and Lake Wright Patman from the USGS[2] and the EPA[3]. The scope of services for this study does not include a detailed evaluation of the impact of system operation on water quality. However, comparing the available data shows that, in most respects, the water quality of the two reservoirs is very similar. A detailed water quality study of storing Lake Wright Patman water in Lake Jim Chapman may be required to fully evaluate the impact on Lake Jim Chapman.

Two parameters pose a problem with respect to federal drinking water standards. Several of the samples exceed the 300 μg/l (0.30 mg/l) total iron standard, and several of the samples exceed the 50 μg/l (0.050 mg/l) manganese standard. Significant iron and manganese concentrations are common in waters throughout east Texas, but they can be treated fairly easily by oxidation (aeration, chlorine dioxide, or permanganate addition) and precipitation as an insoluble hydroxide. Removal of these compounds does not significantly add to the construction cost of a conventional surface water treatment plant, but it may increase the plant’s chemical costs.

Table 5-16
Average Values for Selected Water Quality Parameters

Parameter	Lake Wright Patman Average	Lake Jim Chapman Average
Transparency Secchi Disk (meters)	0.72	0.63
Specific Conductance (Microsiemens/cm At 25 Deg. C)	199	222
Oxygen Dissolved (mg/L)	6.8	6.2
Ph, Water, Whole, Field, Standard Units	7.7	7.7
Nitrogen Ammonia Dissolved (mg/L As N)	0.08	0.15
Nitrogen, Nitrite, Dissolved, mg/L As N	0.01	0.02
Nitrogen Nitrite Plus Nitrate Dissolved (mg/L As N)	0.05	0.02
Phosphorus Dissolved (mg/L As P)	0.03	0.10
Calcium Dissolved (mg/L As Ca)	27	28
Magnesium Dissolved (mg/L As Mg)	2.6	2.8
Sodium Dissolved (mg/L As Na)	13	12
Potassium Dissolved (mg/L As K)	3.4	3.4
Chloride Dissolved (mg/L As Cl)	13.4	6.2
Sulfate Dissolved (mg/L As SO4)	19	13
Fluoride Dissolved (mg/L As F)	0.18	0.21
Silica Dissolved (mg/L As SiO2)	4.5	3.9
Iron Dissolved (ug/L As Fe)	85	329
Manganese Dissolved (ug/L As Mn)	118	162
Carbon, Total Organic (mg/L As C)	9	8*
Alkalinity, Total (mg/L As CaCO3)	69	100*

* Based on a single sample

Other parameters of concern are Total Organic Carbon (TOC) and Alkalinity. Both reservoirs have a high concentration of TOC and may require special treatment to meet the Stage 1 Disinfection/Disinfection Byproduct (D/DBP) Rule (CFR141.135(a) and TAC 290.112).

Another potential concern is the impact of drawdown on water quality. According to the Corps, low water levels have a negative impact on the water quality in the reservoirs, particularly at Lake Wright Patman. However, because the frequency of drawdown is not greatly increased with system operation, the impact on water quality should be acceptable.

5.10 Comparison of System Operation Runs

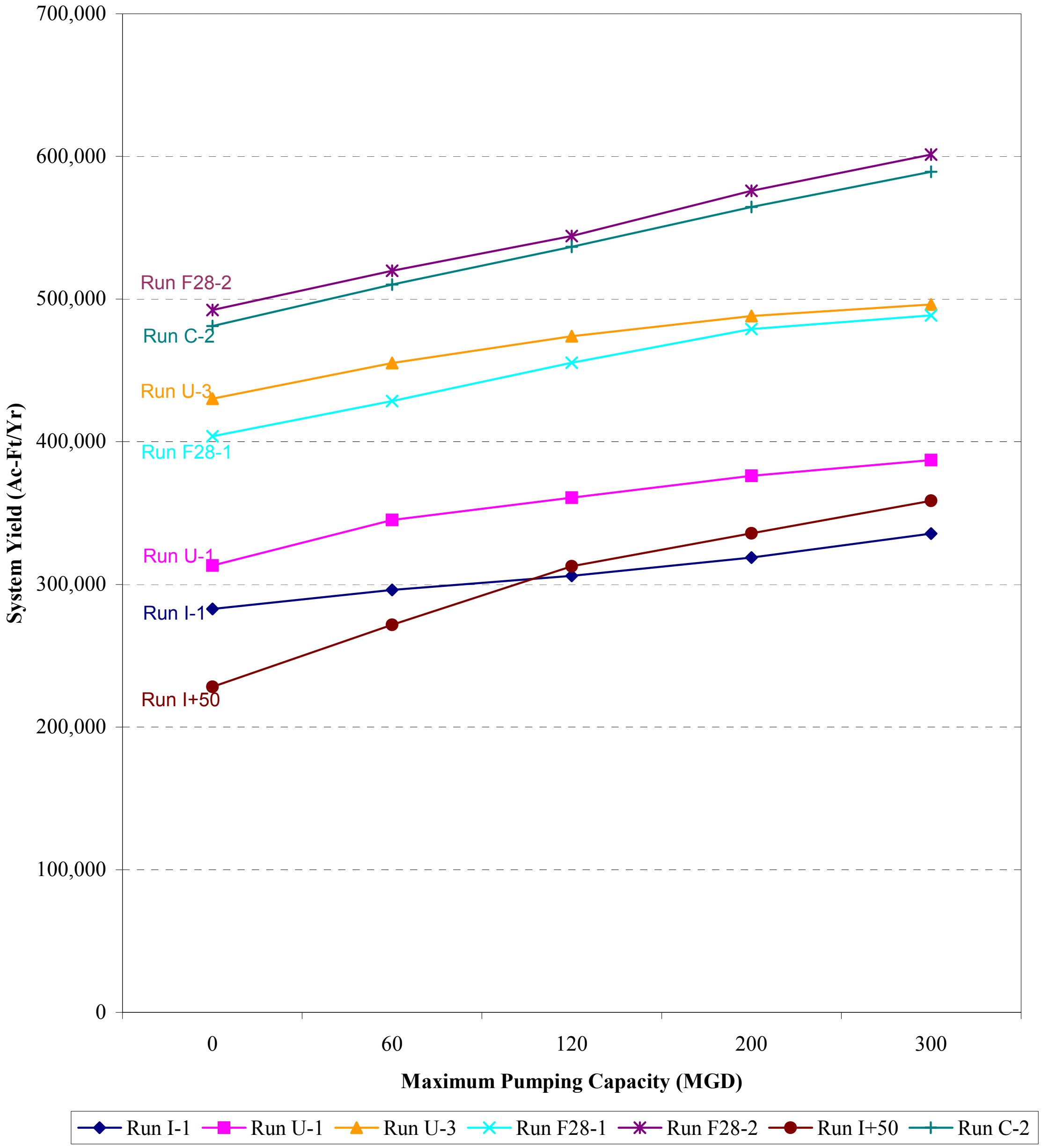
Table 5-17 is a summary of the system operation runs. Figure 5-2 is a graphical representation of the total system yield for each set of runs. The most yield from any of the systems is from Run F28-2, which has a flat conservation pool in Lake Wright Patman at 228.64 feet and uses all of the conservation storage of Lake Wright Patman for supply. The next highest yields are obtained using Lake Wright Patman's ultimate curve, also using all of the conservation storage in the same reservoir. The largest percentage increase in yield due to system operation is for Run I+50, which uses a maximum of 50,000 acre-feet of reallocated flood storage in Lake Wright Patman and a minimum elevation of 220.0 feet in the same reservoir.

Any of the system operation scenarios developed this study require construction of a large pipeline from Lake Wright Patman to Lake Jim Chapman. Achieving a significant gain in supply requires a maximum pumping capacity of at least 200 mgd. Stand-alone yield increases may also require construction of a large capacity pipeline to users outside of the Sulphur Basin.

Table 5-17
Comparison of System Operation Runs

Run ID	Conservation Pool Lake Chapman (feet)	Minimum Patman (feet)	Conservation Pool Lake Patman	Pumping Capacity (MGD)	Yield Chapman (ac-ft/yr)	Yield Patman (ac-ft/yr)	Yield System (ac-ft/yr)	Increase in Yield (ac-ft/yr)	Percent Increase in Yield
I-3	440	215.25	Interim	0	128,600	154,205	282,805	-	-
I-3 60				60	141,855	154,205	296,060	13,255	5%
I-3 120				120	151,861	154,205	306,066	23,261	8%
I-3 200				200	164,597	154,205	318,802	35,997	13%
I-3 300				300	181,300	154,205	335,505	52,700	19%
U-1	440	220	Ultimate	0	128,600	184,591	313,191	-	-
U-1 60				60	161,100	184,000	345,100	31,909	10%
U-1 120				120	177,200	183,600	360,800	47,609	15%
U-1 200				200	193,000	183,200	376,200	63,009	20%
U-1 300				300	203,900	183,200	387,100	73,909	24%
U-3	440	215.25	Ultimate	0	128,600	301,580	430,180	-	-
U-3 60				60	153,600	301,580	455,180	25,000	6%
U-3 100				100	172,400	301,580	473,980	43,800	10%
U-3 200				200	186,600	301,580	488,180	58,000	13%
U-3 300				300	202,600	293,615	496,215	66,035	15%
F28-1	440	220	Max Flat = 228.64	0	128,600	275,313	403,913	-	-
F28-1 60				60	153,219	275,313	428,532	24,619	6%
F28-1 120				120	179,986	275,313	455,299	51,386	13%
F28-1 200				200	203,600	275,313	478,913	75,000	19%
F28-1 300				300	216,600	271,845	488,445	84,532	21%
F28-2	440	215.25	Max Flat = 228.64	0	128,600	363,717	492,317	-	-
F28-2 60				60	156,100	363,717	519,817	27,500	6%
F28-2 120				120	180,500	363,717	544,217	51,900	11%
F28-2 200				200	212,100	363,717	575,817	83,500	17%
F28-2 300				300	237,539	363,717	601,256	108,939	22%
I+50	440	220	Interim +50,000 ac-ft	0	128,600	99,589	228,189	-	-
I+50 60				60	172,100	99,589	271,689	43,500	19%
I+50 120				120	213,100	99,589	312,689	84,500	37%
I+50 200				200	236,100	99,589	335,689	107,500	47%
I+50 300				300	259,046	99,589	358,635	130,446	57%
C-2	Wildlife Management Goals	215.25	Max Flat = 228.64	0	108,533	372,540	481,073	-	-
C-2 60				60	137,633	372,540	510,173	29,100	6%
C-2 120				120	169,706	367,000	536,706	55,633	12%
C-2 200				200	200,533	364,000	564,533	83,460	17%
C-2 300				300	225,533	363,700	589,233	108,160	22%

Figure 5-2
Comparison of System Operation Runs



[1] John C. Jones, Texas Parks and Wildlife Department, *Memorandum on Sulphur River Management Strategy*, July 30, 2002.

[2] United States Geological Survey Water Quality Data for Texas. Available on line at http://waterdata.usgs.gov/tx/nwis/qw.

[3] Environmental Protection Agency STORET Data. Available on line at http://www.epa.gov/STORET/.

6.0 Results

Figures 6-1 through 6-4 compare the following operational scenarios:

- Stand-alone run I-1 – Stand-alone operation with current Lake Wright Patman operation policies, which include the interim curve and full use of supply from Lake Wright Patman's conservation storage above elevation 215.25 feet.
- Stand-alone run U-3 – Stand-alone operation with Lake Wright Patman operation using the ultimate curve and full use of supply from conservation storage above 215.25 feet.
- Stand-alone run F28-2 – Stand-alone operation with Lake Wright Patman using a flat conservation elevation of 228.64 feet and full use of supply from conservation storage above 215.25 feet.
- System run F28-2 200 – System operation with Lake Wright Patman using a flat conservation elevation of 228.64 feet and full use of supply from conservation storage above 215.25 feet with a maximum pumping rate of 120 mgd.

These figures illustrate the relative frequency that a particular elevation or downstream release might occur under a particular set of operating criteria, offering a direct, simple means of comparing the results of various simulation runs. The x-axis gives the percentage of time that an elevation or release greater than or equal to the given value might occur during the 62-year simulation period. For example, Figure 6-1 shows that Lake Jim Chapman is expected to be at or above its conservation storage (elevation 440.0 feet NGVD) about 18% of the time under stand-alone operation.

Figures 6-1 and 6-2 show the frequency of reservoir elevations for Lake Jim Chapman and Lake Wright Patman. Note that the elevations of Lake Jim Chapman are identical for all stand-alone runs (I-3, U-3 and F28-2). In Lake Jim Chapman, the frequencies of elevations above conservation storage are reduced by about 5% with the implementation of system operation. The higher diversion with system operation scenario causes Lake Jim Chapman to go lower during dry periods than without system operation, increasing

Figure 6-1
Frequency of Lake Jim Chapman Elevations
Stand-Alone Runs I-3 (Interim), U-3 (Ultimate) and F28-2 (Flat at 228.64) and System Run F28-2 (Flat at 228.64 and 120 mgd Max Pumping)

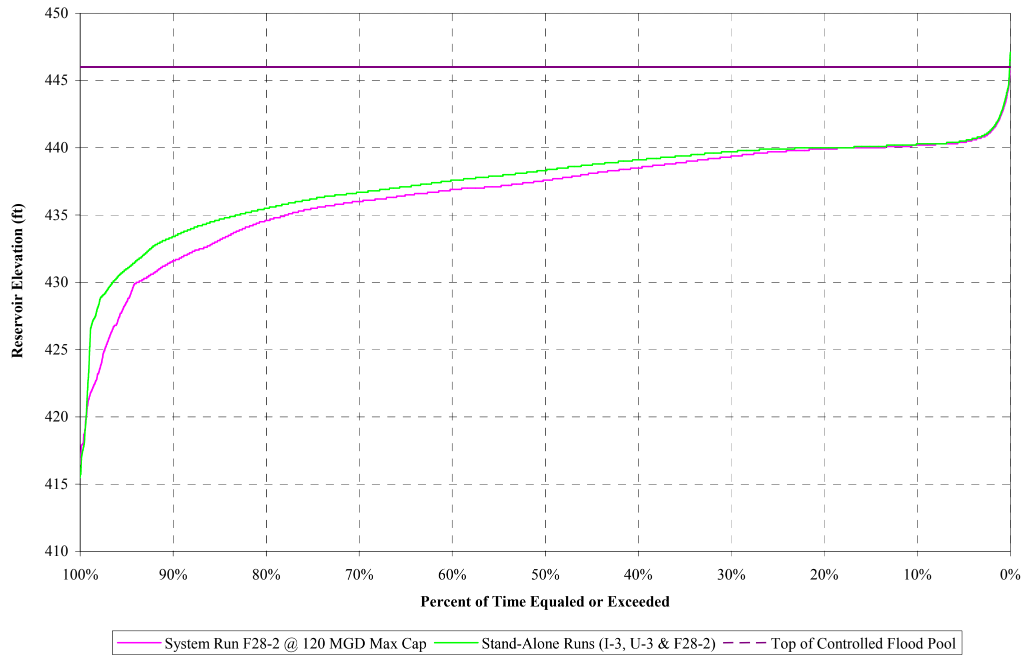


Figure 6-2
Frequency of Lake Wright Patman Elevations
Stand-Alone Runs I-3 (Interim), U-3 (Ultimate) and F28-2 (Flat at 228.64) and System Run F28-2 (Flat at 228.64 and 120 mgd Max Pumping)

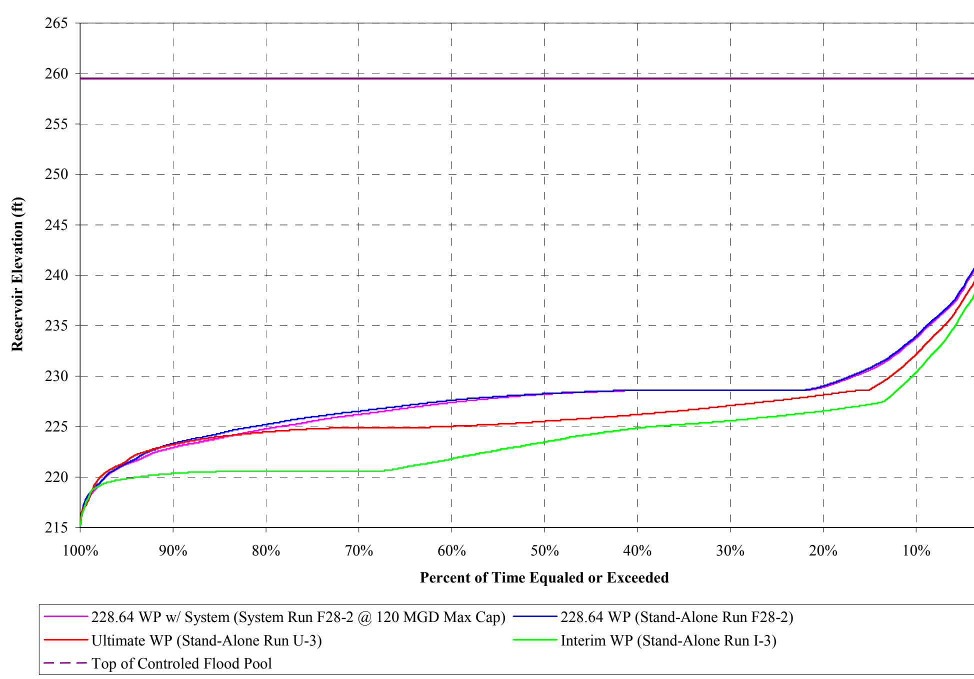


Figure 6-3
Frequency of Water Surface Elevations at Highway 67 Bridge
Stand-Alone Runs I-3 (Interim), U-3 (Ultimate) and F28-2 (Flat at 228.64) and System Run F28-2 (Flat at 228.64 and 120 mgd Max Pumping)

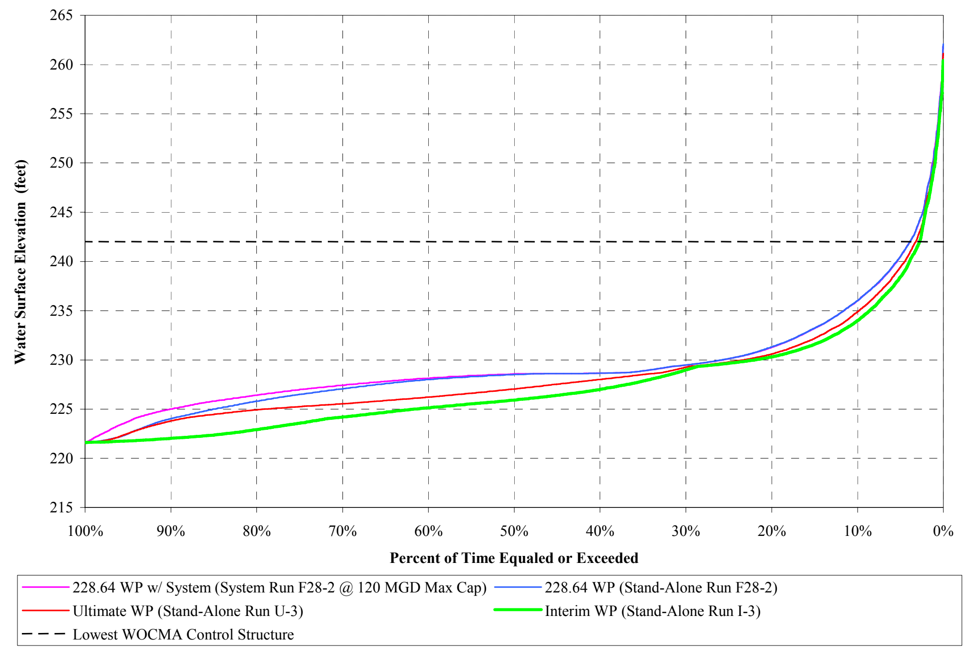
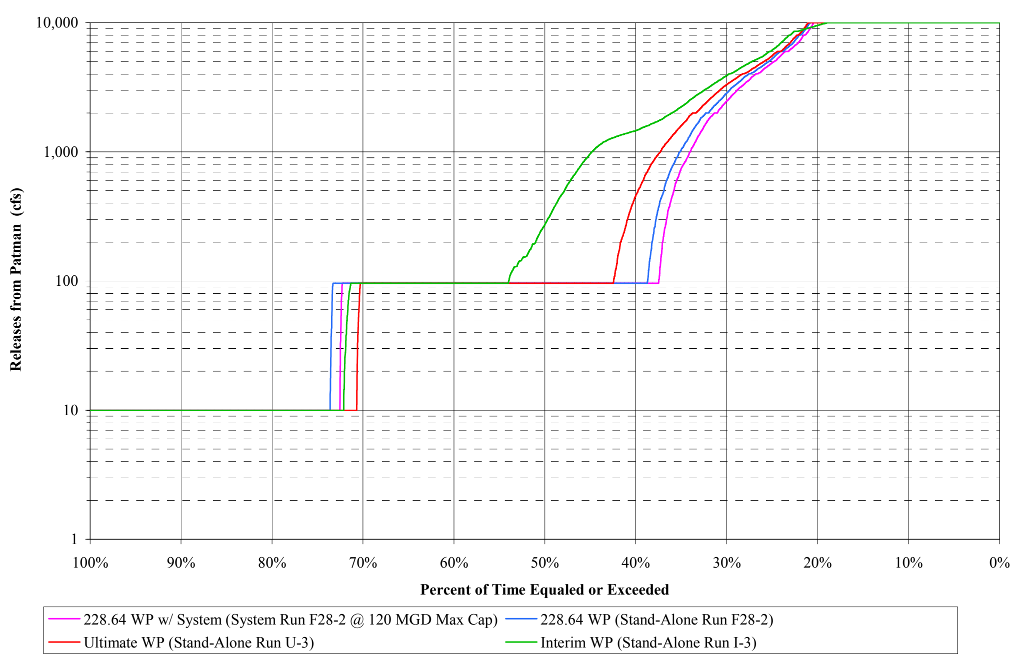


Figure 6-4
Frequency of Releases from Lake Wright Patman
Stand-Alone Runs I-3 (Interim), U-3 (Ultimate) and F28-2 (Flat at 228.64) and System Run F28-2 (Flat at 228.64 and 120 mgd Max Pumping)



the frequency of elevations below 430.0 feet by 5% as well. Other system operation scenarios may have less impact on Lake Chapman elevations. (See Chapter 5.) For Lake Wright Patman, the rule curves with higher conservation storage cause the reservoir to be above 228.64 feet more frequently. However, extreme events above elevation 242.0 feet, which would impact the White Oak Creek WMA, are only slightly higher with higher conservation storage. The frequency of reservoir elevations below 220.0 feet is acceptable in all cases. Implementation of system operation has little impact on reservoir elevations in Lake Wright Patman.

Figure 6-3 compares the range of water surface elevations at the Highway 67 bridge in the White Oak Creek WMA. As noted in Chapter 4, increasing conservation storage in Lake Wright Patman causes only a small increase in out-of-bank water surface elevations (elevations above 230 feet.) Water surface elevations above 242.0 feet, the elevation of the lowest control structure in the White Oak Creek WMA constructed wetlands, are only slightly more frequent with higher conservation storage. In-channel water surface elevations tend to be higher with increased conservation storage in Lake Wright Patman, which may be of benefit for the WMA. Implementation of system operation causes a small reduction in water surface elevations.

Figure 6-4 compares the frequency of downstream releases from Lake Wright Patman under the same four scenarios. Changes in water conservation storage in Lake Wright Patman have more impact than implementation of system operation on downstream releases.

6.1 Conclusions

- Under current conditions, the combined yield of Lake Jim Chapman with a top of conservation storage at 440.0 feet NVGD and Lake Wright Patman using the interim operation curve is 282,805 acre-feet per year. (This assumes that water supply below elevation 220.0 feet in Lake Wright Patman is available for use. If water below 220.0 feet is not available, the combined yield of the two reservoirs is 137,574 acre-feet per year.)
- The largest gains in yield are from reallocation of Lake Wright Patman flood storage to conservation storage and making use of the full conservation storage in

the same reservoir. Changing to Lake Wright Patman's ultimate curve increases supplies to 430,180 acre-feet per year, an increase of 147,375 acre-feet per year. Changing to a flat conservation pool at elevation 228.64 increases the yield to 492,317 acre-feet per year, an increase of 209,512 acre-feet per year. Accessing the increased yield from Lake Wright Patman reallocation would most likely require construction of a large-capacity pipeline.

- System operation of the two reservoirs can increase the overall yield of the system. The maximum yield of the system presented in this report is 601,256 acre-feet per year using a flat conservation pool of 228.64 feet in Lake Wright Patman and constructing a pipeline with a maximum pumping capacity of 300 mgd. This is an increase of 318,451 acre-feet per year, which is more than the yield of the current system. Higher pumping rates can produce even more yield but would likely be impractical to implement. (See Appendix F.)

- System operation of the two reservoirs could result in higher total yields from the basin. However, implementing system operation would require construction of additional large-capacity pipeline and pumping systems. Because of the high cost of transmission and pumping facilities, an economic evaluation should be conducted before committing to implementation of any of the alternatives investigated in this study. System operation is less likely to be economical as a stand-alone project, but it may be economical in conjunction with reallocation of storage in Lake Wright Patman.

- Reallocation of Lake Wright Patman flood storage by raising the conservation pool elevation does not appear to significantly alter flow regimes or increase the frequency of inundation in the White Oak Creek WMA. There may be some benefits to the WMA from raising the pool elevation by increasing in-channel water surface elevations in the lower part of the WMA. However, there may be some negative impacts associated with an increased water table in the WMA.

- In most cases changes in reservoir elevations in Lake Jim Chapman with implementation of system operation appear to be acceptable, although in some of the higher yield scenarios the reservoir goes lower during dry periods.

- Implementation of system operation reduces the frequency of releases from Lake Wright Patman below about 1,000 cfs. The frequency of maximum releases (10,000 cfs) is about the same for all runs.

6.2 Summary

Reallocation of flood storage in Lake Wright Patman appears to be the most promising water supply alternatives considered in this study. Although system operation alone does not appear as promising as reallocation, being able to store water from Lake Wright Patman in Lake Jim Chapman may have considerable economic and operational advantages for potential customers of additional water supply from Lake Wright Patman, as well as supplying a moderate amount of additional supplies. Therefore, it is recommended that storage of water from Lake Wright Patman in Lake Jim Chapman be included as one of the alternatives in further studies. Pursuit of further studies would be dependent upon the interest of a cost-sharing sponsor.

The current study was focused primarily on water availability with minimal cost and impact analysis. Prior to implementation, additional studies would be required. Possible additional studies include but are not limited to:

- An economic evaluation of delivery to the cost-sharing sponsor or other potential users, including detailed cost analyses and operational costs
- Comparison of water from system operation and reallocation to other water supply alternatives
- An analysis of potential environmental impacts associated with changes to Lake Wright Patman operation and implementation of system operation

Comments received from the U.S. Fish and Wildlife Service[1] and the Texas Department of Parks and Wildlife[2] outlined potential issues and concerns regarding the implementation of changes to Lake Wright Patman operation and implementation of system operation, including:

1. Alteration of stream and riverine habitats, riparian areas, and wetlands by inundation.
2. Changes in water quality, including changes in sediment transport, dissolved oxygen, and water temperature.

3. Alteration of flow regimes, both increases and decreases, which make otherwise suitable riverine habitats unfit for aquatic invertebrates, fish, amphibians, and reptiles, and possibly, dependent riparian species.

4. Fluctuation in-stream flows and reservoir levels, which make habitats too unstable for full utilization and may degrade, water quality.

5. Damage to terrestrial habitats and soils, and disruption of runoff patterns related to pipeline.

6. Long-term changes in river hydrology, including possible changes in flow regime, the rivers contribution to ground water, and evapotranspiration due to alterations of stream flow patterns that will have far reaching implications to fish and wildlife.

7. Impacts of changed flow conditions on river form, aquatic and other habitats, the sequence of riffles and pools, lateral migration, and the bed material.

8. Changes in the natural temperature conditions in the reaches below the dams caused by modified storage and release of water from the reservoirs.

9. Impacts on threatened and endangered species: specifically the least tern and bald eagles.

10. Evaluation of a range of potential yields.

11. Project monitoring and adaptive management should be applied.

12. Adequate funding for monitoring and adaptive management.

13. Impacts to both public and private property. An area of particular concern is the privately owned Bassett Creek area is known to be high quality bottomland hardwood habitat.

14. Impacts to public users of the habitats and wildlife that would result from the proposed actions.

15. Influence of potential changes in water table due to higher reservoir elevations in Lake Wright Patman.

16. Impacts on areas surrounding the lakes, particularly on areas set aside for mitigation.

17. Impacts on vegetation affected different flooding regimes, both within the WMA as well as upstream and downstream. This should be done at one-foot contour levels.

---

[1] Carol Hale, U.S. Fish and Wildlife Service, personal communication.

[2] Texas Parks and Wildlife Department, White Oak Creek Meeting Review of Draft Report on System Operation.